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**ARMY PRELIMINARY EVALUATION
IMPROVED COBRA ARMAMENT SYSTEM**

FINAL REPORT

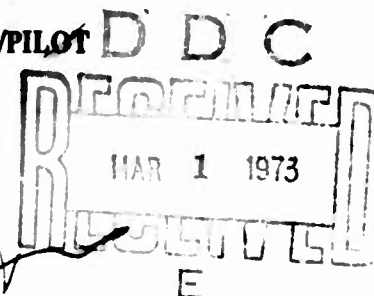
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**UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523**

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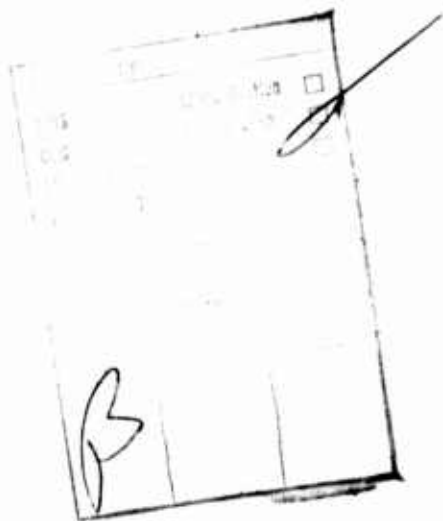
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9 FINAL REPORT. ✓

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UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
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ABSTRACT

The United States Army Aviation Systems Test Activity conducted an Army Preliminary Evaluation of the improved Cobra armament system during the period ~~25 September~~ to 20 October 1972. The testing was accomplished in three phases (each subsequent to the contractor's testing): (1) handling qualities, (2) jettison envelope monitoring and verification, and (3) helmet sight subsystem qualitative evaluation. The testing was conducted at Bell Helicopter Plant No. 6, Arlington, Texas, and at Mojave, California. No deficiencies and seven shortcomings were noted. The shortcomings were (1) undamped lateral-directional oscillations with the stability control augmentation system OFF at 130 knots calibrated airspeed, (2) excessive four-, eight-, and ten-per-rotor-revolution vertical vibrations in symmetrical pull-ups, (3) inability of the helmet sight/M28A1 system to provide adequate range and speed compensation for the 40mm weapon system, (4) intermittent helmet sight reticle operation at the pilot station, (5) uncomfortable orientation of the gunner's left handgrip, (6) canted orientation of the pilot and gunner sight reticles, and (7) poor design of the turret action switch and trigger guard assembly. Seven conditions were noted that failed to satisfy the requirements of the military specification, MIL-H-8501A. The ship's airspeed system position error characteristics should be incorporated in the operator's manual. The helmet sight subsystem boresighting procedure should be improved prior to operational use.

FOREWORD

During the airspeed calibration tests, the radar space-positioning facilities and associated data reduction assistance were provided by the National Aeronautics and Space Administration Flight Research Center, Edwards Air Force Base, California.

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INTRODUCTION

BACKGROUND

1. The armed helicopter has proven its combat effectiveness in the Vietnam conflict. The AH-1G weapons systems, although adequate for the Vietnam tactical environment, are not considered suitable for mid- and high-intensity warfare environments. The Improved Cobra Armament Program was initiated to upgrade the AH-1G to meet the requirements for an armed helicopter in mid- and high-intensity warfare. Development of an improved AH-1G armament capability was initiated, and a development contract was signed on 3 March 1972. The United States Army Aviation Systems Test Activity (USAASTA) was tasked by United States Army Aviation Systems Command (AVSCOM) test directives (refs 1 through 3, app A) to conduct an Army Preliminary Evaluation (APE) on a mock-up version of the AH-1Q Improved Cobra Armament System (ICAS).

TEST OBJECTIVE

2. The overall objective of the test was to provide an early assessment of the handling qualities of the ICAS, verification of the jettison envelope, and a qualitative evaluation of the helmet sight subsystem (HSS).

DESCRIPTION

3. The AH-1G helicopter, modified to the ICAS configuration, has been redesignated the AH-1Q. The ICAS consists of the following: (1) AH-1G helicopter; (2) tube-launched, optically tracked, wire-guided (TOW) missile launchers with associated control equipment; (3) modified XM26 sight subsystem; and (4) helmet sight subsystem. The test AH-1Q helicopter, serial number 70-16019, manufactured and modified by the Bell Helicopter Company (BHC), is a tandem, two-place, single-main-rotor helicopter powered by a T53-L-13 turbine engine. Small tapered swept mid wings are provided with two hardpoint locations each, for external stores. In the ICAS loading configuration, the helicopter can be equipped with an XM200, 19-round rocket launcher installed on each inboard wing stores station. Each outboard wing stores station can be loaded with either one or two TOW missile launchers (two TOW missiles per launcher). The aircraft is equipped with an integral chin turret and was flown with the M28A1 armament subsystem. A mocked-up telescopic sight unit (TSU) nose structure was installed on the test aircraft. A detailed description of the AH-1G helicopter, the M28A1 armament subsystem, and the XM200 rocket launcher is included in the operator's manual (ref 4, app A). Appendix B contains a further description and photographs of the AH-1Q modifications and the associated weight and balance changes are contained in appendix C.

SCOPE OF TEST

4. The APE was conducted at BHC Plant No. 6, Arlington, Texas, and the Flight Test Research, Inc. facility, Mojave, California. The tests were conducted in three phases (para 8) during the period 25 September to 20 October 1972. During the flight test program, 19 flights were conducted for a total of 17.9 hours, of which 11.4 hours were productive. The AH-1Q helicopter was evaluated to determine the effect of the modifications on handling qualities and airspeed position error. Handling qualities and vibrations were evaluated with respect to the applicable requirements of military specification MIL-H-8501A (ref 5, app A). The contractor's demonstration of an operational jettison envelope was monitored and verified to ensure that jettison could be accomplished without causing structural damage or endangering the crew. The helmet sight/M28A1 was qualitatively evaluated for target acquisition and tracking compatibility.

5. The three test configurations consisted of the following: (1) configuration A had one XM200 launcher, with 19 inert 2.75-inch rockets, on each inboard wing station and two TOW launchers, with four missile handling rounds, on each outboard station; (2) configuration B had clean wing stations; and (3) configuration C had one instrumentation pod (similar to an XM200 launcher) on each inboard station. Test conditions are shown in table 1. Flight restrictions and operating limitations applicable to this evaluation are contained in the operator's manual (ref 4, app A), as modified by the safety-of-flight releases (refs 6 through 8).

METHODS OF TEST

6. Established flight test techniques and data reduction procedures were used during the program. The test methods are described briefly in the Results and Discussion section of this report. Flight test data were recorded on magnetic tape, video tape, high-speed motion picture cameras, and manually from calibrated instrumentation located on the pilot instrument panel. A detailed listing of the test instrumentation is contained in appendix D. A pace vehicle was used during sideward, rearward, and slow-speed forward testing. Airspeed calibrations were conducted using the trailing bomb method and radar space positioning. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app E).

Table 1. Test Conditions.¹

Test	Configuration ²	Test Gross Weight (lb)	Average Density Altitude (ft)	Average Outside Air Temperature (°C)	Trim Airspeed (KCAS) ³
Sideward flight	A	9430	1300	21.5	⁴ Zero to 32
Rearward flight	A	9160	1300	21.5	⁴ Zero to 32
Control positions in trimmed forward flight	A A	9160 8960	1300 4900	21.5 9.5	⁴ Zero to 32 41 to 167
Collective-fixed static longitudinal stability	A A	9230 9230	4860 5570	20.5 23.5	62 132
Static lateral-directional stability	A A	9230 9230	4860 5570	20.5 25.6	61 131
Dynamic stability	A A	9240 9340	6040 5050	19.5 21.5	131 131
Controllability	A A A A	9180 9310 9300 9240	1500 5150 4020 6000	21.5 20.5 22.0 19.5	Zero ⁵ 97 97 130
Maneuvering stability	A	9310	4900	9.5	113
Simulated engine failure characteristics	A A A	9210 8880 8980	2790 2130 3060	21.5 20.5 25.5	62 119 131
Level flight airspeed calibration	B	8070	4840	9.5	38 to 112
Level flight and dive airspeed calibration	B	8130	4780	10.0	93 to 173
Autoration airspeed calibration	B	7860	3840	16.8	47 to 107
Climb airspeed calibration	B	7860	5940	4.5	47 to 107
Helmet sight subsystem/M28A1 compatibility	C	8520	2750	9.0	100 to 160

¹Rotor speed: 324 rpm.

Center-of-gravity locations: FS 195.8 to FS 196.4 (mid) for all tests.

²Configuration A: one XM200 and two TOW launchers each wing.

Configuration B: clean wing station.

Configuration C: one instrument pod (simulated XM200 launcher) each inboard wing station.

³Knots calibrated airspeed unless otherwise noted.⁴Knots true airspeed, in ground effect.⁵Out of ground effect.

CHRONOLOGY

7. The chronology of the ICAS APE is as follows:

Test directive received	18	April	1972
Test plan forwarded	21	August	1972
Phase I testing started	25	September	1972
Contractor resumed control of aircraft	30	September	1972
Phase II started, monitor contractor jettison testing	3	October	1972
Phase II completed, verification of jettison envelope	5	October	1972
Contractor resumed control of aircraft	6	October	1972
Phase I testing completed	11	October	1972
Phase III testing started	19	October	1972
Phase III testing completed	20	October	1972
Preliminary report forwarded	7	December	1972
Product manager debriefing	8	December	1972

RESULTS AND DISCUSSION

GENERAL

8. An Army Preliminary Evaluation of the ICAS was conducted in three phases: (1) handling qualities, (2) jettison envelope monitor/witness and verification, and (3) the HSS qualitative evaluation. Handling qualities were evaluated during forward flight, sideward and rearward flight, maneuvering flight, and autorotational entries. Static and dynamic stability and controllability tests were performed. Jettison tests, conducted by the contractor, were monitored and then verified with additional jettisons by test team personnel from USAASTA. The HSS was qualitatively evaluated during 7.62mm and 40mm weapon system firing. The handling qualities of the AH-1Q were found to be essentially the same as the AH-1G helicopter, and wing stores could be safely jettisoned within the operating envelope of the helicopter. No deficiencies and seven shortcomings were noted. The shortcomings were (1) undamped lateral-directional oscillations with the stability and control augmentation system (SCAS) OFF at 130 knots calibrated airspeed (KCAS), (2) excessive four-, eight-, and ten-per-rotor-revolution (4/rev, 8/rev, and 10/rev) vertical vibrations during symmetrical pull-ups, (3) inability of the helmet sight/M28A1 system to provide adequate range and airspeed compensation for the 40mm weapon system, (4) intermittent reticle operation of the pilot's HSS, (5) uncomfortable orientation of the gunner's weapons-firing control handgrip, (6) canted orientation of the pilot and gunner sight reticles, and (7) poor design of the turret action switch and trigger guard assembly. Seven conditions were noted that fail to satisfy the requirements of the military specification, MIL-H-8501A. The ship's airspeed system position error characteristics should be incorporated in the operator's manual. The HSS boresighting procedure should be improved prior to operational use.

HANDLING QUALITIES

Control System Characteristics

9. Control system characteristics were evaluated on the ground with the engine and rotor secured, and electrical and hydraulic power furnished by external sources. Control forces were measured on the pilot flight controls (aft cockpit). Breakout forces, including friction, were determined by recording the forces required to obtain initial movement of the control position indicators. The cyclic control pattern is presented in figure 1, appendix F. Control system forces, as a function of control position, are presented in figures 2 through 5. The results of the control system evaluation are summarized in table 2. Control system forces were determined to be essentially the same as those of a production AH-1G helicopter. The longitudinal, collective, and directional control system forces, as shown in table 2, did not satisfy the requirements of paragraphs 3.2.6, 3.3.11, 3.3.13, and 3.4.2 of MIL-H-8501A (ref 5, app A) but were not objectionable during flight. The control system characteristics evaluated are satisfactory for the anticipated TOW mission.

Table 2. Control System Characteristics.

Test		MIL-H-8501A Requirements		Test Results
		Maximum	Minimum	
Longitudinal cyclic	Breakout force including friction	1.5 lb	0.5 lb	1.5 lb
	Gradient	2.0 lb/in.	0.5 lb/in.	2.0 lb/in.
	Full throw (fwd)	8.0 lb	NA	11.5 lb ¹
	Full throw (aft)	8.0 lb	NA	10.5 lb ¹
Lateral cyclic	Breakout force including friction	1.5 lb	0.5 lb	1.5 lb
	Gradient	2.0 lb/in.	0.5 lb/in.	1.7 lb/in.
	Full throw (right)	7.0 lb	NA	8.0 lb ¹
	Full throw (left)	7.0 lb	NA	8.5 lb ¹
Collective	Breakout force including friction	3.0 lb	1.0 lb	4.0 lb ^{1, 2}
	Full throw	7.0 lb	NA	12.0 lb ¹
Directional	Breakout force including friction	7.0 lb	3.0 lb	2.0 lb ¹
	Gradient	NA	NA	10.0 lb/in.
	Full throw (right)	15.0 lb	NA	20.0 lb ¹
	Full throw (left)	15.0 lb	NA	30.0 lb ¹

¹Failed to satisfy the requirements of the military specification, MIL-H-8501A.

²Adjustable friction: zero.

Sideward, Rearward, and Slow-Speed Forward Flight Characteristics

10. Control margins and handling qualities for in-ground-effect (IGE) hover were evaluated from 28 knots true airspeed (KTAS) in rearward flight to 33 KTAS in forward flight and to 30 KTAS in left and right sideward flight. Airspeeds for the conditions shown in table 1 were determined by using a calibrated ground pace vehicle. The results of these tests are presented in figures 6 and 7, appendix F. Qualitative evaluation of critical wind azimuth revealed control margins similar to an AH-1G helicopter equipped with a tractor tail rotor.

11. A neutral lateral control gradient position was noted between 5 and 28 KTAS in left sideward flight (fig. 6, app F). This characteristic did not degrade the pilot's ability to stabilize at these airspeeds (HQRS 3). From 5 KTAS in left sideward flight to 32 KTAS in right sideward flight, the control position changes were linear with lateral control displacement required in the direction of flight. Right pedal displacement was required for left sideward flight and left pedal for right sideward flight except near hover and above 12 KTAS in right sideward flight, where no additional directional control displacements were required. The neutral directional control position characteristics were not noticeable, or objectionable to the pilot during the left sideward flight maneuver and only minimal compensation was required to stabilize at a desired airspeed (HQRS 3). During right sideward flight above 12 KTAS, a minimum of 12 percent of left directional control remained. Longitudinal control position changes from hover did not exceed 6 percent (0.6 inch) and presented no control problem. Within the scope of this test, the control position characteristics in sideward flight are similar to an AH-1G helicopter equipped with a tractor tail rotor.

12. Rearward and slow-speed forward flight test results, as shown in figure 7, appendix F, indicate that the longitudinal control position changes with airspeed were stable (aft control displacement to increase rearward airspeed) except above 17 KTAS in rearward flight where a control position reversal occurred. Also, between 2 to 11 KTAS in forward flight, neutral control position requirements were noted. These longitudinal control position characteristics did not degrade the pilot's ability to stabilize at these speeds (HQRS 3). Lateral control position changes from hover did not exceed 11 percent (0.9 inch). The magnitude of the directional control position change from hover to 28 KTAS in rearward and 33 KTAS in forward velocities did not exceed 28 percent (1.4 inch). For each control axis, adequate control margins were available throughout the airspeed range tested. Within the scope of this test, the sideward and rearward flight characteristics are satisfactory for the anticipated TOW mission.

Control Positions in Trimmed Forward Flight

13. Control positions in trimmed forward flight were evaluated from 42 to 167 KCAS with the SCAS ON. Tests were conducted at the conditions shown in table 1. The results of the test are presented in figure 8, appendix F.

14. The longitudinal control trim positions from 42 to 125 KCAS were essentially linear with increasing forward displacement required with increasing airspeed. From 125 to 167 KCAS in diving flight, a slight reduction in the forward longitudinal control position requirements with airspeed occurred, but it was not noticeable to the pilot.

Collective-Fixed Static Longitudinal Stability

15. The static longitudinal stability characteristics were evaluated at trim airspeeds of 62 and 132 KCAS for the conditions shown in table 1. The helicopter was trimmed in steady-heading, ball-centered flight at the desired trim airspeed. Then, with the collective control held fixed, the aircraft was stabilized at incremental speeds greater and less than the trim speed. The test results are presented in figure 9, appendix F.

16. The static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed, was stable (forward control displacement required to maintain an increased airspeed and aft displacement to maintain decreased airspeed) at 62 KCAS. A slight reduction in stability was noted at the 132-KCAS trim airspeed. For the conditions tested, the collective-fixed static longitudinal stability characteristics are satisfactory for the anticipated TOW mission.

Static Lateral-Directional Stability

17. Static lateral-directional stability characteristics were evaluated at trim airspeeds of 61 and 131 KCAS and the conditions shown in table 1. The aircraft was trimmed in wings-level, ball-centered flight at the desired airspeed. With the collective control fixed, and maintaining a steady-heading flight path over the ground at the trim airspeed, the aircraft was stabilized at incremental sideslip angles, right and left. Test results are presented in figures 10 and 11, appendix F.

18. Static directional stability, as indicated by the variation of directional control position with sideslip, was strongly positive (right pedal required for left sideslip and left pedal required for right sideslip). Directional control position variation with angle of sideslip was linear at both airspeeds. Dihedral effect, as indicated by the variation of lateral control position with sideslip, was positive (lateral control displacement in the direction of sideslip) and linear at both airspeeds. Side-force characteristics, as indicated by the variation of bank angle with sideslip, were nearly neutral at 61 KCAS and qualitatively, were positive at 131 KCAS. For the conditions tested, the static lateral-directional characteristics are satisfactory for the anticipated TOW mission.

Dynamic Stability

19. The longitudinal and lateral-directional dynamic stability characteristics were evaluated in forward flight at airspeeds of 97 and 130 KCAS with SCAS ON and OFF at the conditions listed in table 1. Short-period oscillations (simulating gust response) were evaluated by rapidly displacing the desired control 1 inch from

trim for a duration of 0.5 second, and then returning the control to the trim position. The lateral-directional oscillations were evaluated by releasing the helicopter from steady-heading sideslips and by pulsing the pedals (control doublets). The long-period characteristics were evaluated by slowing the helicopter, with aft cyclic control, to an airspeed 15 knots below trim and then returning the controls to the trim position. Time histories of representative dynamic response characteristics are presented in figures 12 through 17, appendix F.

20. The short-period oscillations of the helicopter, SCAS ON, were similar for all test conditions and were essentially deadbeat in all axes. With SCAS OFF, roll coupling was noted following the aft longitudinal pulse, which caused the aircraft to roll right. This condition did not cause the pilot any control problems. Oscillations in the yaw axis appeared to be damped.

21. The long-term aircraft response characteristics in the longitudinal axis were evaluated with SCAS ON and OFF at 97 KCAS. The response following release from 15 knots off trim was oscillatory and damped to near zero in approximately 2 cycles with SCAS ON and 3 cycles with SCAS OFF. For the conditions investigated, the longitudinal dynamic characteristics are satisfactory for the anticipated TOW mission.

22. Lateral-directional oscillations, evaluated with SCAS ON, were essentially a yawing motion for both airspeeds. At 97 and 130 KCAS, SCAS OFF, there was an undamped yaw-to-roll oscillation (3 to 1 ratio). The undamped oscillations, SCAS OFF, were objectionable at the 130-KCAS airspeed and required considerable pilot compensation to stabilize the helicopter (HQRS 5). The undamped lateral-directional oscillations at 130 KCAS, SCAS OFF, are a shortcoming, correction of which is desirable. Qualitatively, the lateral-directional oscillations were similar to the standard AH-1G helicopter. The effect of the undamped lateral-directional oscillations on the TOW mission should be evaluated during follow-on testing.

Controllability

23. Controllability characteristics were evaluated at 97 and 130 KCAS and for out-of-ground-effect (OGE) hover. Tests were conducted with SCAS ON at both airspeeds and SCAS OFF at 97 KCAS. The aircraft was trimmed at the test conditions (table 1) and single-axis, control step inputs were applied to the longitudinal, lateral, and directional controls, using a mechanical fixture to obtain the desired control displacement during the input. Helicopter responses were recorded until recovery was initiated by the pilot. Test results are presented in figures 18 through 23, appendix F.

24. There were no objectionable or excessive delays in the development of angular velocity in response to longitudinal, lateral, or directional control displacements. Angular accelerations were in the proper direction within 0.2 second after control displacements. In comparison with the standard AH-1G helicopter, controllability results were essentially unchanged.

25. The maximum longitudinal response (maximum rate per inch of control displacement), SCAS ON, occurred 1.0 second after the control input. Pitch rates were 6 degrees per second (deg/sec), nose down and nose up, with fore and aft 1-inch inputs. Maximum responses with SCAS OFF were slightly higher and occurred at 1.1 seconds after the input. Helicopter longitudinal sensitivity (maximum angular acceleration per inch of control displacement) with SCAS ON occurred 0.2 second after initiation of control input (figs. 18 and 19, app F) and resulted in a 12-degree/second/second (deg/sec²) nose-down acceleration and a 10- to 15-deg/sec² nose-up acceleration. Slightly smaller accelerations appeared with SCAS OFF. Maximum roll response for a 1-inch input was 19 deg/sec, left, and 20 deg/sec, right, at 1.0 second with SCAS ON (figs. 20 and 21). Maximum roll acceleration, lateral sensitivity, was 32 deg/sec², left, and 28 deg/sec², right, after 0.3 second. SCAS OFF roll response was similar to SCAS ON, and lateral sensitivity had a slightly smaller acceleration. Maximum directional response (yaw rates) occurred at 1.4 seconds in an OGE hover and at 0.8 second in forward flight. The maximum yaw rates for a 1-inch step input were 30 deg/sec to the right, OGE, and 13 deg/sec, left, and 16 deg/sec, right, in forward flight. Directional sensitivity (accelerations) peaked at 0.2 second for forward flight, and were 30 deg/sec², left and right. There were no appreciable differences between SCAS ON and SCAS OFF. For the conditions investigated, the controllability characteristics were satisfactory for the anticipated TOW mission.

Maneuvering Stability

26. Maneuvering stability characteristics were evaluated at the conditions shown in table 1 with SCAS ON. The variation of longitudinal control position and control force with normal acceleration was determined by trimming the aircraft in coordinated level flight at 113 KCAS and then stabilizing the aircraft at incremental bank angles in steady turns, both left and right. Collective control (power) and airspeed were held constant, and the helicopter was allowed to descend during the maneuver. Data were recorded at each stabilized bank angle. The results of the maneuvering stability evaluation are presented in figure 24, appendix F.

27. The variation of longitudinal control position with normal acceleration (stick-fixed stability) was positive and essentially linear at all trim airspeeds. The longitudinal control position gradient was approximately 3.6 inches per g. The variation of longitudinal control force with normal acceleration (stick-free stability) was qualitatively evaluated as being positive and linear. The longitudinal control force gradient was approximately 7 pounds per g for all airspeeds tested. For the conditions investigated, the variation of longitudinal control position and force with airspeed is satisfactory for the anticipated TOW mission.

Simulated Engine Failure Characteristics

28. The response of the helicopter to a sudden engine failure was evaluated in climbs, powered descents, and in forward level flight for the conditions shown in table 1. Engine failure was simulated by rapidly rolling the throttle control to the flight-idle position. Flight controls were held fixed either for 2 seconds

following the simulated power loss, until the minimum transient rotor speed (250 rpm) occurred, or until the pilot deemed recovery necessary. Representative time histories of aircraft response and recovery are shown in figures 25 through 27, appendix F. Test results are presented in table 3.

Table 3. Simulated Engine Test Results.¹

Flight Condition	Entry Calibrated Airspeed (kt)	Entry Torque (psi)	Collective Control Delay Time (sec)	Time to Roll 10 Degrees (sec)	Rotor Speed Decay Rate (rpm/sec)
Level flight	66	19	2.3	NA ²	23
Level flight ³	65	19	2.3	2.7	18
Level flight	106	41	2.8	NA ²	26
Level flight	119	48	1.5	⁴ 1.4	28
Level flight ³	119	47	1.4	⁴ 1.3	23
Climb	75	35	2.5	2.5	26
Climb	70	46	2.5	NA ²	26
Climb ³	62	49	2.5	NA ²	35
Dive	131	35	3.9	⁴ 1.6	28
Dive ³	131	35	1.5	⁴ 1.5	25
Dive	131	42	2.2	⁴ 1.9	27

¹ SCAS ON unless noted.

Rotor speed: 324 rpm.

² Condition was not reached.

³ SCAS OFF.

⁴ Exceeded the requirements of the military specification, MIL-H-8501A.

29. Aircraft responses following a simulated sudden engine failure in level flight up to 100 KCAS were a relatively mild left yaw and roll. An abrupt left roll occurred during the 131-KCAS dive throttle chop. Rotor speed decay averaged approximately 26 rpm/sec for all tests, except for a SCAS OFF high power climb where the decay rate was 35 rpm/sec. The 2-second delay requirement of MIL-H-8501A could not be attained in high-power level flight at 119 KCAS or in a powered dive, SCAS OFF, at 131 KCAS due to the roll attitude attained. The abrupt roll following power loss provided an immediate cue which was detectable before rotor speed had approached the minimum rpm. The limit of 10 degrees of attitude change in 2 seconds in pitch, roll, or yaw attitude of paragraph 3.5.5.1 of MIL-H-8501A was exceeded only in roll but adequate lateral control was available for recovery. Table 3 shows those test results which exceeded the specification limit. Within the scope of this test, aircraft response characteristics following simulated sudden engine failures are similar to a standard AH-1G and are satisfactory for the anticipated TOW mission.

MISCELLANEOUS

Weight and Balance

30. The aircraft weight and longitudinal cg were determined prior to testing. The basic aircraft weight, including instrumentation, was 6341 pounds with the cg located at fuselage station (FS) 200.9 (aft). The instrumentation was estimated to weigh 472 pounds. The resulting aircraft basic weight was calculated to be 5869 pounds with a cg at FS 202.5 (aft). The aircraft weight breakdown is presented in table 4.

Table 4. Test Helicopter Weight and Balance.

Item	Weight (lb)	Fuselage Station (in.)
Basic aircraft	5869	202.5
Aircraft with test instrumentation	6341	200.9
Two TOW missile launchers with missiles (outboard)	632	201.2
Two XM200 rocket launchers with 19 10-pound warhead rockets (inboard)	1058	196.1
Pilot with parachute	247	136.0
Gunner with parachute	215	85.0
Fuel	1050	203.6
Total at engine start	9553	196.3

31. The external stores configuration consisted of an XM200 launcher mounted on each inboard wing stores station and two mock-up TOW missile launchers mounted on each outboard wing stores station. Nineteen (10-pound warhead) inert rockets were loaded in each XM200. Each TOW launcher was loaded with two inert handling rounds. A handling round consists of a capped, empty TOW launcher tube ballasted to simulate the TOW missile.

32. During testing, the aircraft was loaded to an anticipated mission loading. Nominal cg was FS 197.2. Anticipated cg variation through normal expenditure of stores is from FS 196.6 to FS 198.0. Appendix C contains a comparison of the weight and balance for an AH-1G and an AH-1Q. The takeoff gross weight and cg of an AH-1Q in the mission configuration is included.

Vibration Characteristics

33. Vibration data were gathered during symmetrical pull-ups at 130, 135, and 141 KCAS. The cg normal acceleration (FS 196.7) vibration sensor data were used to analyze the vertical cg vibration levels. The vibration characteristics are presented in figures 28 through 30, appendix F, for frequencies from zero to 510 hertz (Hz).

34. The vibration data were primarily harmonic in nature, with the main rotor being the primary vibration source. The highest vibration levels (0.61g) occurred at 43.2 Hz (8/rev) and were recorded during a 1.45-g symmetrical pull-up at 135 KCAS. This acceleration was considered the most severe condition. Although the vibration limits of MIL-H-8501A do not apply to the cg location, similar vibration levels were experienced in the cockpit. High vibration levels also occurred at the 4/rev and 10/rev frequencies. These high amplitudes caused discomfort to the crew. The effect of the vibration characteristics on the TOW mission should be evaluated during follow-on testing. The excessive 4/rev, 8/rev, and 10/rev vibrations during symmetrical pull-up are a shortcoming which should be corrected. Qualitatively, the vibration characteristics of the AH-1Q helicopter were similar to a standard AH-1G helicopter.

Airspeed System Calibration

35. The pitot tube was relocated from the nose to the upper pylon of the aircraft (para 2, app B). An airspeed calibration was conducted at the conditions shown in table 1 to determine the new position error of the ship's airspeed system. Trailing bomb and radar tracking methods were used to calibrate the ship's airspeed system in level flight, dive, climb, and autorotation. The effects of sideslip in level flight and autorotation were also evaluated. The results of these tests are presented in figure 31, appendix F.

36. At 40 knots indicated airspeed (KIAS) in level flight and autorotation, the position error was +3.0 knots. As the airspeed increased to 122 KIAS, the position error decreased to zero and then crossed over to a negative position error. At 176 KIAS in a dive, the position error was -5.5 knots. In climb, the position error was -14.5 knots at 60 KIAS, decreasing gradually to -5.5 knots at 110 KIAS. The

position error in sideslips of ± 10 degrees at 70, 90, and 110 KIAS did not differ from the position error of wings-level, ball-centered flight. The relocation of the pilot tube has changed the AH-1Q helicopter position error. The airspeed position error in the AH-1Q is suitable for operational use and should be incorporated in the operator's manual; however, a reduction in the position error in climb is desirable for improved operational use.

Jettison Envelope

37. Jettison testing was conducted by the contractor to demonstrate a safe jettison envelope. The AH-1G helicopter flight envelope, as modified by the safety-of-flight release (refs 6 through 8, app A), was used. Jettison tests performed by the contractor were monitored by USAASTA. The USAASTA conducted two verification jettisons: one at 170 KCAS, in a dive, with two TOW launchers loaded; and one at 120 KCAS, in autorotation, with two TOW launchers empty. Five-degree, or greater, right sideslip was used during each drop. The contractor tests were conducted at the flight condition shown in table 5. A one-half ball out or greater right sideslip was used for all drops. A special jettison circuit was installed by the contractor to provide an asymmetric jettison capability (right wing outboard or inboard stores only) during the envelope demonstration and verification testing. High-speed motion picture camera and video tape camera data (app D) were obtained to verify that adequate clearance existed during each drop. Data were also recorded by similar cameras on board a chase helicopter.

38. The film data showed a minimum clearance of approximately 6 inches for all TOW launcher drops. The contractor also satisfactorily demonstrated that the XM200 rocket launcher could be jettisoned from the modified outboard wing stores station. The XM158A1 and the XM200 rocket launchers were satisfactorily jettisoned from the right inboard wing stores station with one TOW launcher outboard. When two TOW launchers are installed, a salvo jettison circuit is automatically activated because of the inadequate clearance to jettison inboard stores in this configuration (para 3, app B). The salvo circuit was not evaluated. From the conditions investigated, it appears that external wing stores can be safely jettisoned from the AH-1Q helicopter within the established operating envelope without causing structural damage or endangering the crew.

Table 5. Contractor Jettison Conditions.

Test Point			Wing Stores Jettisoned	
Flight Condition	Indicated Airspeed (kt)	Contractor-Obtained Sideslip Data (deg)	Outboard	
			Launchers ¹	Loading ²
Dive	170	9.1	Two TOW	Full
Autorotation	120	15.9	Two TOW	Full
Dive	170	5.3	Two TOW	Critical
Autorotation	120	9.2	Two TOW	Critical
Dive	170	7.9	Two TOW	Empty
Autorotation	120	2.6	Two TOW	Empty
Dive	150	14.5	One TOW	Empty
Dive	170	Unknown ³	One TOW	Full
Dive	170	4.0	One TOW	Critical
Dive	170	Unknown ³	One TOW	Empty
Autorotation	120	7.9	One TOW	Full
Autorotation	120	Unknown ³	One TOW	Critical
Autorotation	120	2.6	One TOW	Empty
Autorotation	120	5.5	XM200	Empty
Flight Condition	Indicated Airspeed (kt)	Contractor-Obtained Sideslip Data (deg)	Inboard	
			Launcher ⁴	Loading ²
Dive	170	Unknown ³	XM200	Empty
Dive	170	5.5	XM200	Critical
Dive	170	8.2	XM158A1	Empty

¹Empty XM200 loaded inboard.

²Critical loading: Launcher loaded such that the center of thrust from the forced ejection system does not pass through the center of mass, causing the launcher to spin, after ejection, toward the aircraft or other wing stores.

³Indicates instrumentation failure of angle-of-sideslip readout.

⁴Empty TOW loaded outboard.

Helmet Sight Subsystem Evaluation

39. The HSS was qualitatively evaluated by firing the 7.62mm and the 40mm weapons at various ranges, estimated 300 to 1300 meters. Altitudes of 400 to 1000 feet above ground level were used during the testing. Takeoff conditions were as shown in table 1. Prior to the evaluation, the HSS horesighting was checked. The ship's system range compensator (range adjustment control 500, 1000, and 1500 meters) was used for both weapons. The effectiveness of the range compensator was determined by firing from known distances and observing round impacts with respect to the target. The capability of the pilot or gunner to track and effectively fire on randomly selected targets was determined while the helicopter was being maneuvered by the pilot.

40. With the range compensator set at 1000 meters, the pilot and gunner could effectively engage targets with the 7.62mm weapon by placing initial bursts on target. Conversely, neither the pilot nor the gunner could adequately place initial fire on the target or adjust firing with the 40mm weapon, even with considerable crewmember compensation. When firing from ranges of 500 meters or less and with turret azimuths of 30 to 60 degrees, target misses of 70 to 100 meters (estimated) in the direction of flight were common. The inability of the helmet sight/XM28A1 system to provide adequate range and speed compensation for the 40mm weapon is a shortcoming, for which correction is desirable.

41. The HSS was worn during three flights, totaling 3 hours of operation. No discomfort was noted by either crewmember, as a result of the helmet sight link (photos B-14 and B-15, app B) being attached to the helmet or from the increased helmet weight. Both pilot and gunner were initially aware that the link arm was connected, but were not conscious of it during the firing. There was no apparent degradation of pilot flight performance due to the system. However, there was a noticeable increase in pilot workload due to the requirement to track a target and continue to fly the helicopter. The additional effort was created by the requirement for the pilot to move his head, rather than just his eyes, to position the helmet sight on the target. Normal procedure was to position the helmet sight straight ahead, depress the action switch, and then move both the turret and helmet sight to the target line. This procedure was followed to prevent the turret from being damaged by large, rapid movements. This procedure can possibly be modified after more experience is obtained on the effect of rapid movements on the turret. Care was also exercised by the pilot so as not to move his helmet rapidly back and forth from the target line to the cockpit to check the instruments.

42. During the evaluation, the reticle in the pilot HSS operated intermittently and both the pilot and gunner reticles were canted with respect to the vertical and horizontal axes. The intermittent operation of the pilot helmet sight reticle and the canted orientation of both helmet sight reticles are shortcomings, correction of which are desired.

43. A handgrip, similar to the cyclic control grip, was provided in the gunner's cockpit to simulate the TOW sight left handgrip. The HSS turret action switch,

trigger, and guard assembly were located on this handgrip. The position of the handgrip was uncomfortable to the gunner due to its orientation. The uncomfortable orientation of the gunner's left handgrip is a shortcoming, for which correction is desirable. Repeated difficulty was experienced in raising the safety cover and engaging the action and firing switches. The poor design of the turret action switch and trigger guard assembly is a shortcoming, correction of which is desirable.

44. It was noted that during the contractor's preparation for the HSS qualification testing, considerable effort was required to boresight the helmet sight/M28A1 system. A simplified boresighting system should be incorporated for use by operational units. Within the scope of the evaluation, the HSS is acceptable for ICAS development testing.

CONCLUSIONS

GENERAL

45. The following general conclusions were reached upon completion of testing:

- a. The handling qualities and vibration characteristics of the AH-1Q are similar to a standard AH-1G helicopter with tractor tail rotor.
- b. The relocation of the pitot tube has changed the ship's airspeed position error from the basic AH-1G (para 36).
- c. Jettison of the wing stores can be safely accomplished within the operating envelope of the AH-1Q helicopter (para 38).
- d. The helmet sight subsystem is acceptable for further ICAS development testing (para 44).
- e. No deficiencies and seven shortcomings were identified during the evaluation.

SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

46. Correction of the following shortcomings is desirable:

- a. Undamped lateral-directional oscillations with SCAS OFF at 130 KCAS (para 22).
- b. Excessive 4/rev, 8/rev, and 10/rev vertical vibrations during symmetrical pull-ups (para 34).
- c. Inability of the helmet sight/M28A1 system to provide adequate range and speed compensation for the 40mm weapon system (para 40).
- d. Intermittent operation of the pilot helmet sight reticle (para 42).
- e. Improper orientation of the pilot and gunner sight reticles (para 42).
- f. Uncomfortable orientation of the gunner's left handgrip (para 43).
- g. Poor design of the turret grip action switch and trigger guard assembly (para 43).

SPECIFICATION COMPLIANCE

47. Within the scope of this test, the AH-1Q helicopter failed to meet the requirements of the military specification, MIL-H-8501A, as listed below. In areas where data were available for comparison, the ICAS specification compliance is similar to the AH-1G with the tractor tail rotor.

a. Paragraph 3.2.6 - Longitudinal control full throw forces exceeded the 8.0-pound limit by 2.5 pounds aft (31 percent) and 3.5 pounds forward (43 percent) (para 9).

b. Paragraph 3.3.13 - Lateral control full throw forces exceeded the 7.0-pound limit by 1.0 pound, right (14 percent), to 1.5 pounds, left (21 percent) (para 9).

c. Paragraph 3.4.2 - Collective control breakout forces exceeded the 3.0-pound limit by 1.0 pound (33 percent) (adjustable friction OFF) (para 9).

d. Paragraph 3.4.2 - Collective control full throw forces exceeded the 7.0-pound limit by 5.0 pounds (71 percent) (para 9).

e. Paragraph 3.3.13 - Directional control breakout forces were below the 3.0-pound minimum limit by 1.0 pound (33 percent) (para 9).

f. Paragraph 3.3.11 - Directional control full throw forces exceeded the 15.0-pound limit by 5.0 pounds, right (33 percent), and 15.0 pounds, left (100 percent) (para 9).

g. Paragraph 3.5.5.1 - Roll attitude exceeded 10 degrees within 2 seconds following sudden engine failure (para 29).

RECOMMENDATIONS

- 48. The shortcomings, correction of which is desirable, should be corrected as soon as possible (para 46).
- 49. The effect of the undamped lateral-directional oscillations on the TOW mission should be evaluated during follow-on testing (para 22).
- 50. The effect of the vibration characteristics on the TOW mission should be evaluated during follow-on testing (para 34).
- 51. The ship's airspeed system position errors should be incorporated in the operator's manual; however, a reduction in the position error in climb is desirable for improved operational use (para 36).
- 52. A simplified boresighting system for the helmet sight/M28A1 system should be incorporated for use by operational units (para 44).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-EFT, 18 April 1972, subject: Improved Cobra Armament Program (ICAP).
2. Message, AVSCOM, AMSAV-EFT, 08-25, 23 August 1972, Unclassified, subject: Army Preliminary Evaluation, Improved Cobra Armament Program (ICAP).
3. Message, AVSCOM, AMSAV-EFT, 09-10, 15 September 1972, Unclassified, subject: Improved Cobra Armament Program (ICAP).
4. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971.
5. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities: General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.
6. Letter, AVSCOM, AMSAV-EF, 25 September 1972, subject: Safety-of-Flight Release for USAASTA APE 1 on AH-1G/ICAS (Project 72-18).
7. Message, AVSCOM, AMSAV-EFT, 10-04, 5 October 1972, Unclassified, subject: Safety-of-Flight Release for USAASTA for Jettison Testing of TOW Missiles and Pods from the AH-1G.
8. Message, AVSCOM, AMSAV-EFT, 10-16, 18 October 1972, Unclassified, subject: Safety-of-Flight Release for Demonstration of HSS/M28A1 on the AH-1G.

APPENDIX B. IMPROVED COBRA ARMAMENT SYSTEM DESCRIPTION

FUSELAGE

1. The AH-1Q fuselage is a standard AH-1G fuselage with modifications to incorporate the TOW missile weapon system (photos B-1 through B-8). All structure forward of fuselage station (FS) 46.0 has been removed. The bulkhead at FS 46.0 has been structurally reinforced and an XM26 sight subsystem (telescopic sight unit (TSU)) has been mounted to the bulkhead. The TSU is a nose-mounted stabilized sight with a field of view ± 110 degrees in azimuth and $+30$ to -60 degrees in elevation. On the test aircraft, a mock-up TSU was installed (photos B-9 and B-10). The tail boom will be structurally reinforced on the production aircraft as a result of previous static firing tests. The test helicopter tail boom and stabilizer were not modified.

PITOT SYSTEM

2. The pitot tube has been relocated from the nose (FS 21.8, water line (WL) 58.0, buttline (BL) 0.0) to the left forward side of the upper pylon (FS 169.3, WL 125.1, BL -17.4) (photo B-11). This change was necessitated by the modification of all structure forward of FS 46.

WING CONFIGURATION

3. The outboard wing stores station and wing tip have been modified to incorporate a forced ejection system and a TOW launcher elevating mechanism (photos B-12 and B-13). An automatic elevating mechanism was not installed on the test aircraft. There were provisions for manual elevation and depression of the TOW launchers on the test helicopter for testing at several angles of attack. A circuit is installed so that, in the eight-missile configuration, selection of either the inboard or both positions on the jettison selector switch (pilot station) will result in a salvo jettison. The circuit is automatically activated by the installation of the lower TOW launcher. This circuit was installed because there is insufficient clearance to jettison inboard wing stores with two TOW launchers installed on the outboard wing stores station.

TOW CONTROL EQUIPMENT

4. Equipment installed to operate the TOW missiles includes: (1) a power supply, sight signal amplifier and missile command amplifier with associated racks mounted in the tail boom; and (2) a TOW control panel, missile status panel, indicator panel, and missile hand control which are installed in the gunner cockpit. The pilot wing stores control panel is modified to indicate TOW missile status. Table C-1, appendix C, lists weights and locations. This equipment was not installed in the test aircraft.

HELMET SIGHT SUBSYSTEM

5. The HSS consists of pilot and gunner linkage assemblies (photos B-14 and B-15) to pick up helmet line of sight, and an electronics interface assembly to transmit the signals from the helmet sight with the turret. This equipment was installed in the test aircraft. A standard SPH4 helmet was modified by the addition of the helmet sight and a linkage assembly attaching fixture to provide target acquisition and tracking.

TOW MISSILE LAUNCHERS

6. The TOW missile launcher consists of a box beam with handling round retainers on the forward end and round retainers/blast deflectors on the aft end. A mount is located on the top of the beam with two sets of attachment points. The inward attachment points are equipped with shackles to suspend the launcher from a standard stores pylon. The outer attachment points are used to mate-up two launchers (maximum, due to the electrical circuitry). The launchers are coupled with two safetied drift pins. A mount is located on the bottom of the beam with a set of attachment points to mate with the attachment points on the upper launcher. Two TOW control boxes are mounted between the inboard attachment points. A locking arm bridges the mount on each side and arms the missile when secured. The blast deflectors are connected to the box beam by a hinge at the bottom and on a pinned attachment point at the top. The weight of each launcher is 60 pounds.

7. The TOW missiles are loaded into the launcher by pulling the drift pins at the top of the locking lever and blast deflector and allowing them to rotate down (photo B-16). An Infantry standard TOW missile launching tube with missile is then inserted into the launcher. The blast deflector and locking arm are rotated back into place, secured, and the missile is ready for firing. Each firing tube, with missile, weighs 51.5 pounds.

GENERAL

8. Principal dimensions and general data for the AH-1Q are as follows:

Main Rotor

Diameter	44.0 ft
Disc area	1520.5 sq ft
Solidity	0.0651
Number of blades	2

Blade chord	27 in.
Blade twist	-0.455 deg/ft
Airfoil section	9.33 percent symmetrical special

Tail Rotor

Diameter	8.5 ft
Disc area	56.74 sq ft
Solidity	0.105
Number of blades	2
Blade chord	8.41 in.
Blade twist	0.0 deg
Airfoil section	NACA 0010 modified

Fuselage

Overall length (with rotor turning)	52 ft, 11 in.
Overall height (to top of pylon)	10 ft, 2 in.
Overall width	3 ft
Skid tread	7 ft

Elevator

Area (total)	15.2 sq ft
Span	6 ft, 2 in.
Airfoil	Inverted Clark Y

Vertical Fin

Area	18.5 sq ft
Airfoil	Special camber
Height	5.5 ft

Wing

Span	10.33 ft
Area (total)	27.8 sq ft
Incidence	14 deg
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024

IMPROVED COBRA ARMAMENT SYSTEM PHOTOGRAPHS

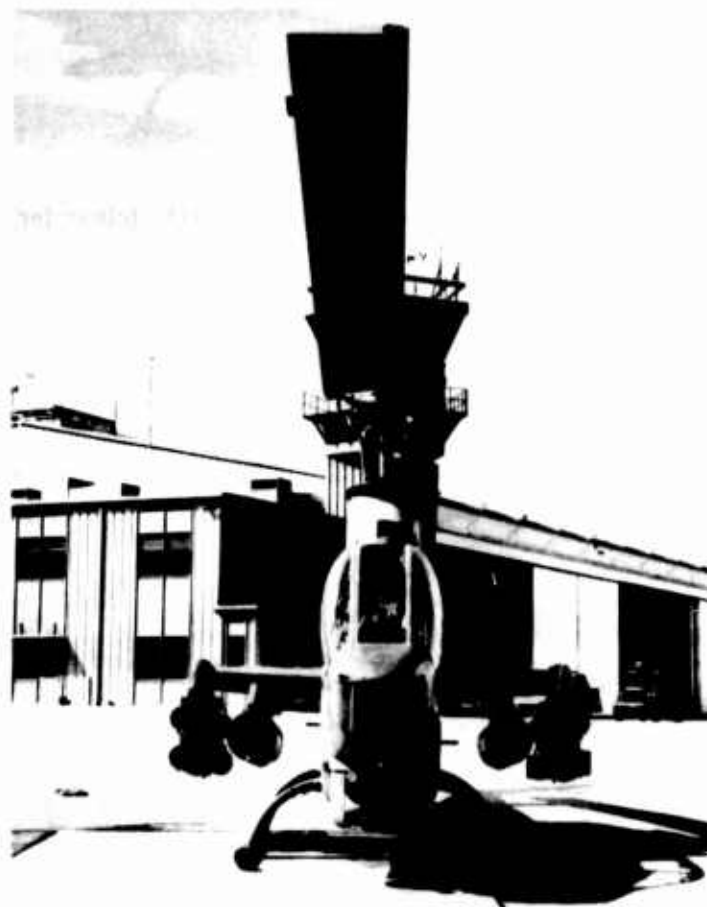


Photo B-1. Front View, AH-1Q Helicopter.



Photo B-2. Left Front View, AH-1Q Helicopter.



Photo B-3. Left-Side View, AH-1Q Helicopter.



Photo B-4. Left Rear View, AH-1Q Helicopter.

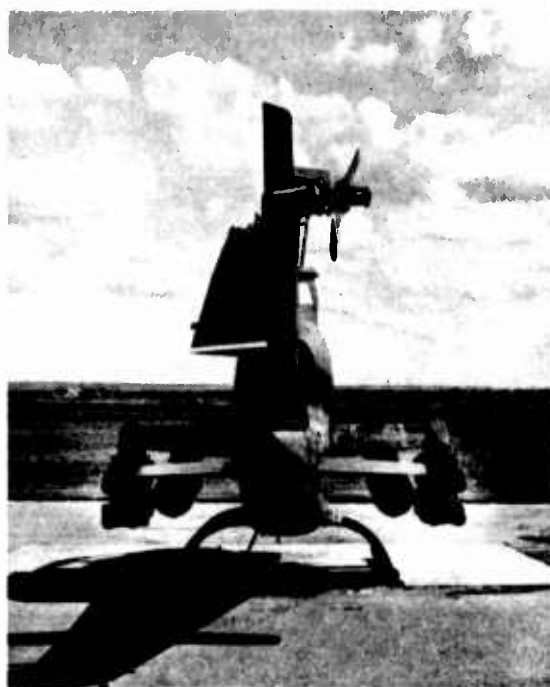


Photo B-5. Rear View, AH-1Q Helicopter.



Photo B-6. Right Rear View, AH-1Q Helicopter.



Photo B-7. Right View, AH-1Q Helicopter.



Photo B-8. Right Front View, AH-1Q Helicopter.

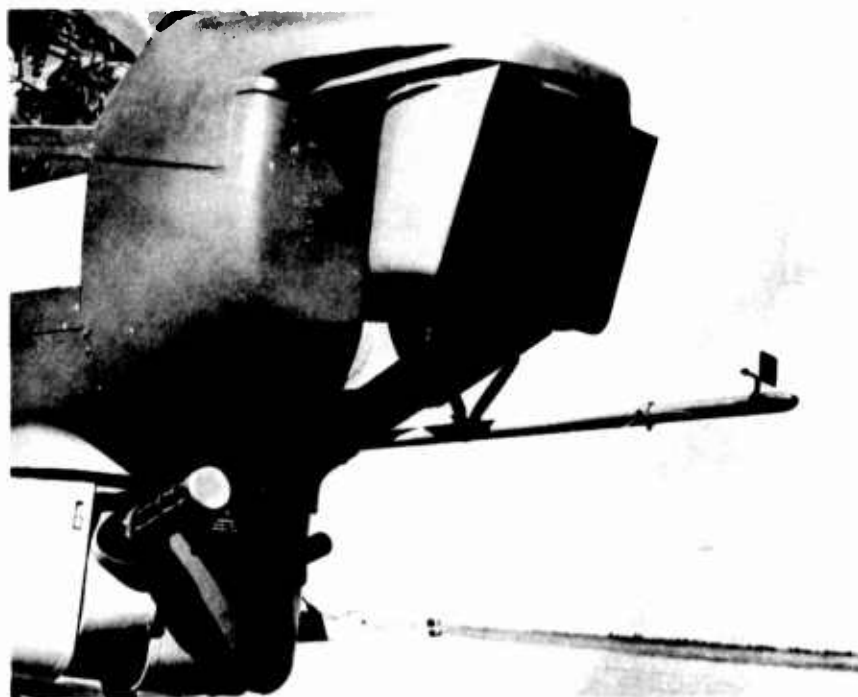


Photo B-9. XM26 Sight Mock-Up and Sideslip Boom, Right Front View.



Photo B-10. XM26 Sight Mock-Up and Sideslip Boom, Left Front View.



Photo B-11. Pitot Tube Installation.

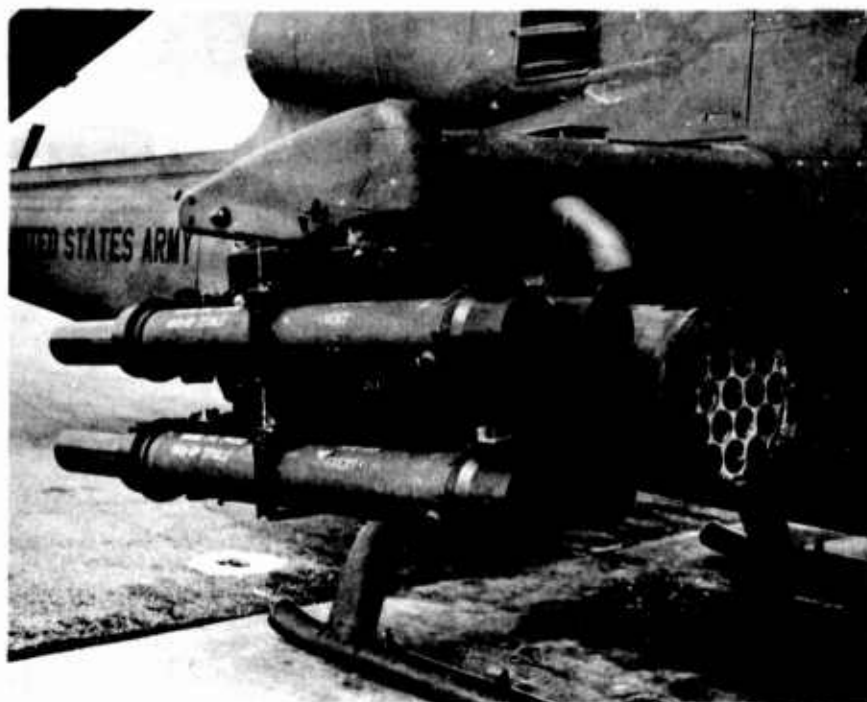


Photo B-12. Right-Side Wing Stores, Right Front View.

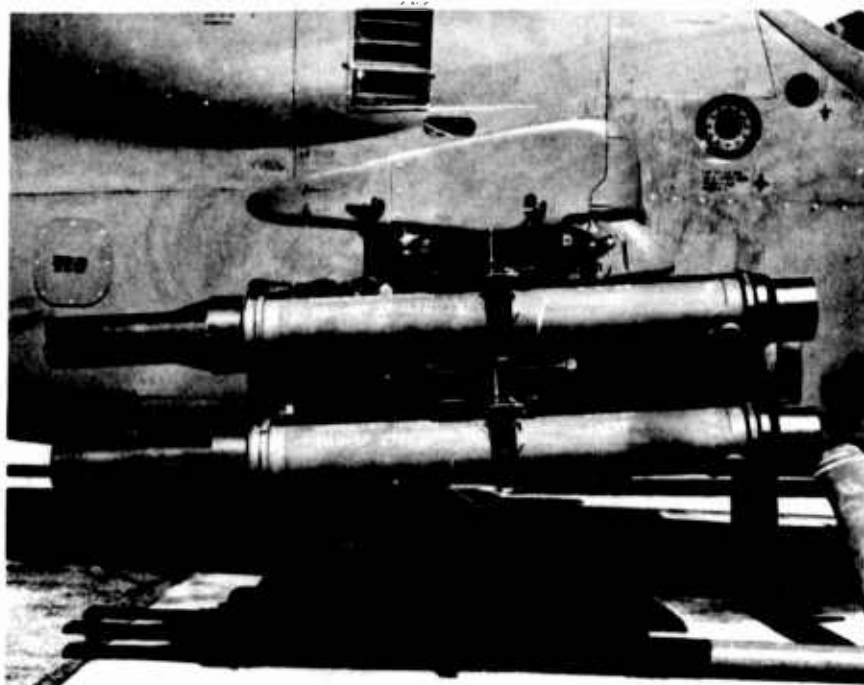


Photo B-13. Right-Side Wing Stores, Side View.



Photo B-14. Helmet Sight Link, Guide Rods, and Extension Cable, Aft Cockpit.

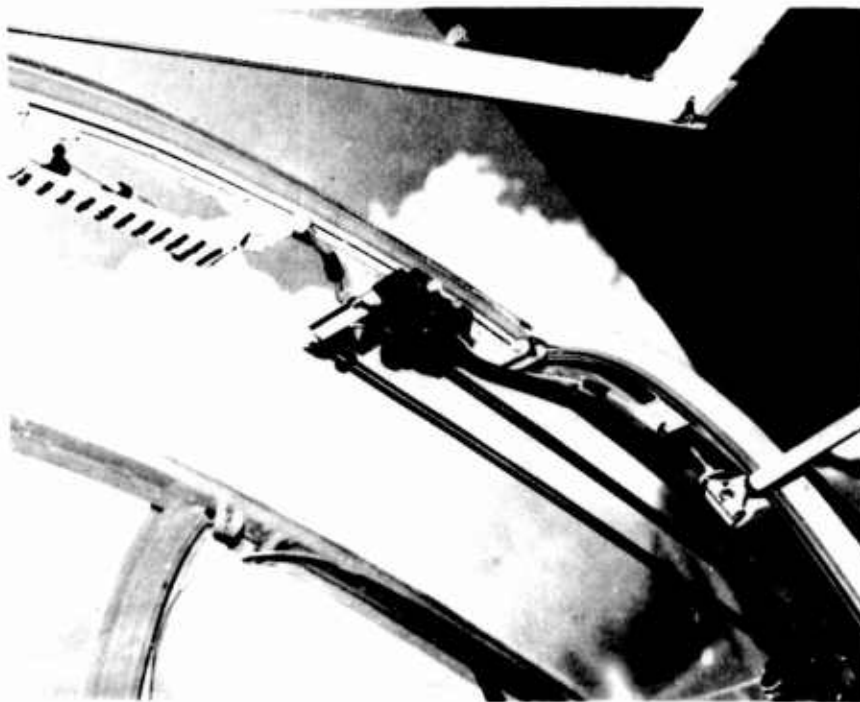


Photo B-15. Helmet Sight Link, Guide Rods, and Extension Cable, Forward Cockpit.



Photo B-16. Left-Side Wing Stores, TOW Blast Deflectors Dropped.

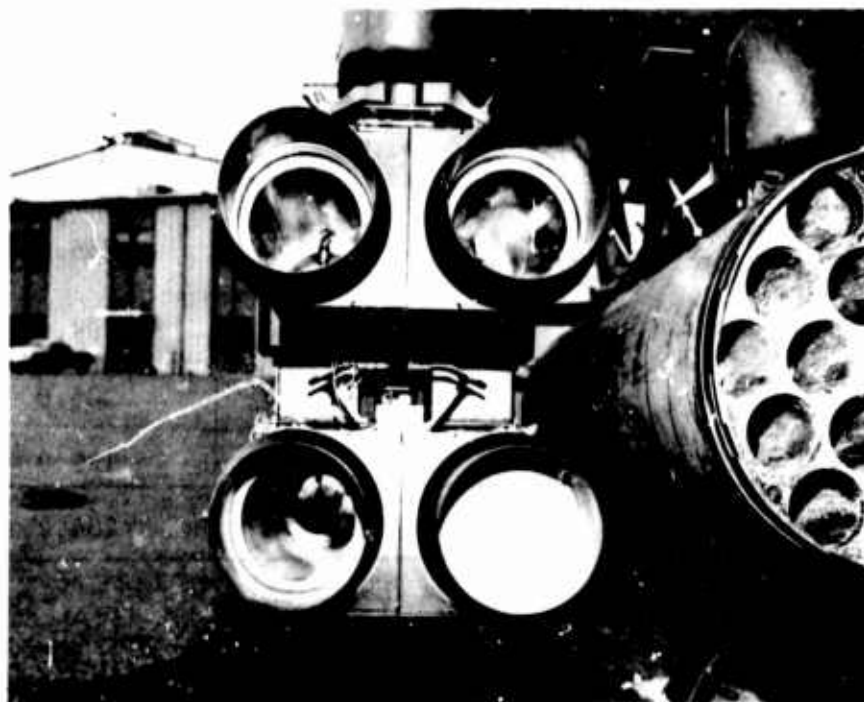


Photo B-17. Front View of Dummy TOW Launcher with Three Ballasted Firing Tubes and One Inert Missile.

APPENDIX C. WEIGHT AND BALANCE

Table C-1. AH-1Q Dry Weight.

Item	Weight (lb)	Fuselage Station (in.)
Basic AH-1G	5769	205.0
Sight assembly (TSU)	126	42.0
Amplifier assembly and rack (SCA)	28	331.0
TOW control panel (TCP)	6	64.0
Amplifier assembly and rack (MCA)	19	333.0
Control assembly -- hand (SHC)	4	64.0
Power supply and rack (EPS)	26	348.0
Missile status panel assembly (MSP)	1	112.0
Indicator assembly (PSI)	3	110.0
Linkage assembly (pilot)	4	153.0
Linkage assembly (gunner)	4	110.0
Electronics interface assembly	19	169.0
Extension cable	2	148.0
Miscellaneous (airframe, electrical, hydraulics)	156	266.0
Helmet modification	1	109.0
Fairing pylons	9	205.0
Stores pylons	80	199.0
Basic AH-1Q dry weight	6256	204.2

Table C-2. AH-1Q Mission Loading Eight-Missile Configuration.

Item	Weight (lb)	Fuselage Station (in.)
AH-1Q dry weight	6256	204.2
Nonexpendable stores ¹	202	151.2
Pilot	200	135.0
Gunner	200	83.0
Four TOW missile launchers	240	204.2
Two M200 launchers	278	198.7
Fuel (130 gallons)	845	203.8
7.62mm ammunition (500 rds) and 40mm ammunition (50 rds)	76	110.0
Eight TOW missiles	412	199.3
Thirty-eight 2.75 FFAR rockets (10-pound warheads)	791	195.0
AH-1Q mission configuration	9500	197.2

¹Includes trapped fuel, engine oil, trapped engine-transmission and gearbox oil, pallet ammunition drum (40mm), and ammunition drum (7.62mm).

APPENDIX D. TEST INSTRUMENTATION

Instrumentation was installed in the test aircraft by the Bell Helicopter Company (photos D-1 through D-6). The magnetic tape data system was located in the ammunition bay for all testing except turret firing. During turret firing, the tape system was installed in pods hung from the inboard wing stores sections. Cameras were installed on the helicopter tail boom (photo D-6) during jettison tests.

Pilot Panel

Airspeed (sensitive)
Altitude
Rotor speed (sensitive)
Longitudinal control position
Lateral control position
Pedal control position
Longitudinal control position
Lateral control position
Pedal control position
Angle of sideslip (boom system)
Center-of-gravity normal acceleration
Outside air temperature

Magnetic Tape

Longitudinal control position
Lateral control position
Pedal control position
Collective control position
Pitch attitude
Roll attitude
Yaw attitude
Pitch rate
Roll rate
Yaw rate
Center-of-gravity load factor
Sideslip angle
Throttle position

Camera Equipment

Tail boom high-speed camera
Right toe skidgear high-speed camera
Video tape camera
Video tape recorder

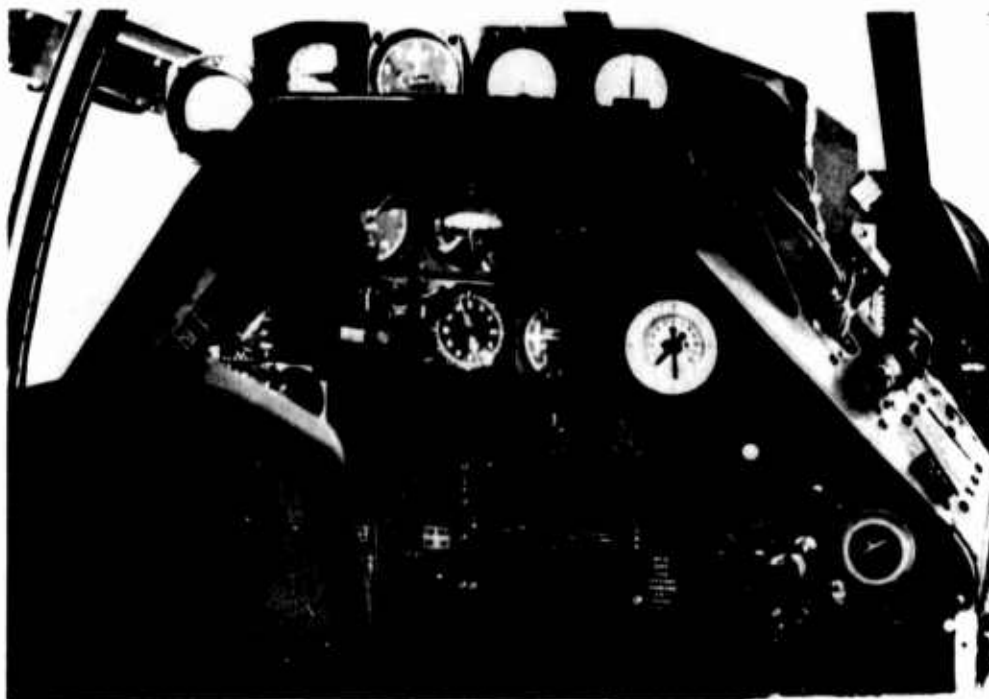


Photo D-1. Aft Cockpit Auxiliary Instrumentation Panel.

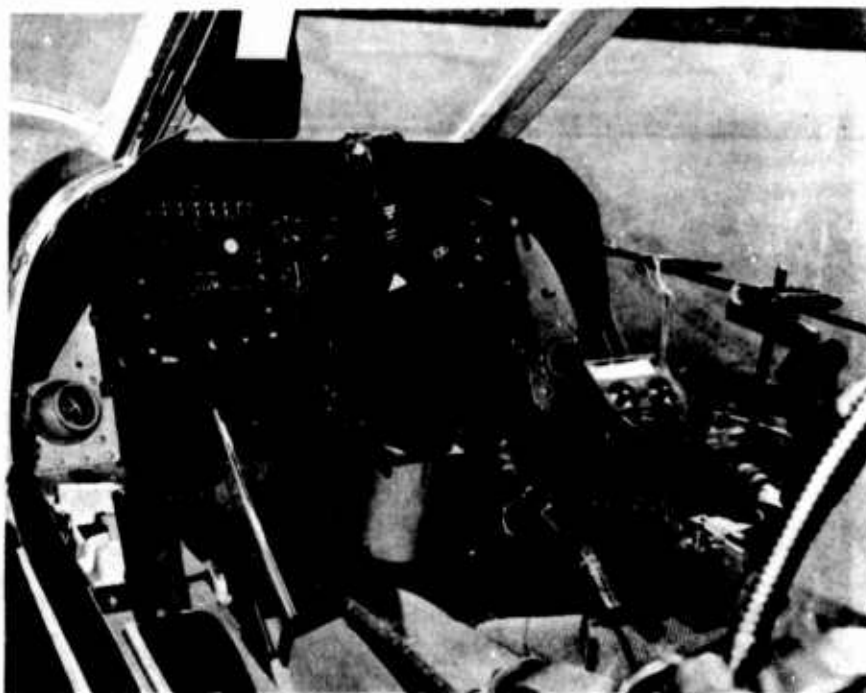


Photo D-2. Forward Cockpit: Control Fixture Set for Longitudinal Step Input.

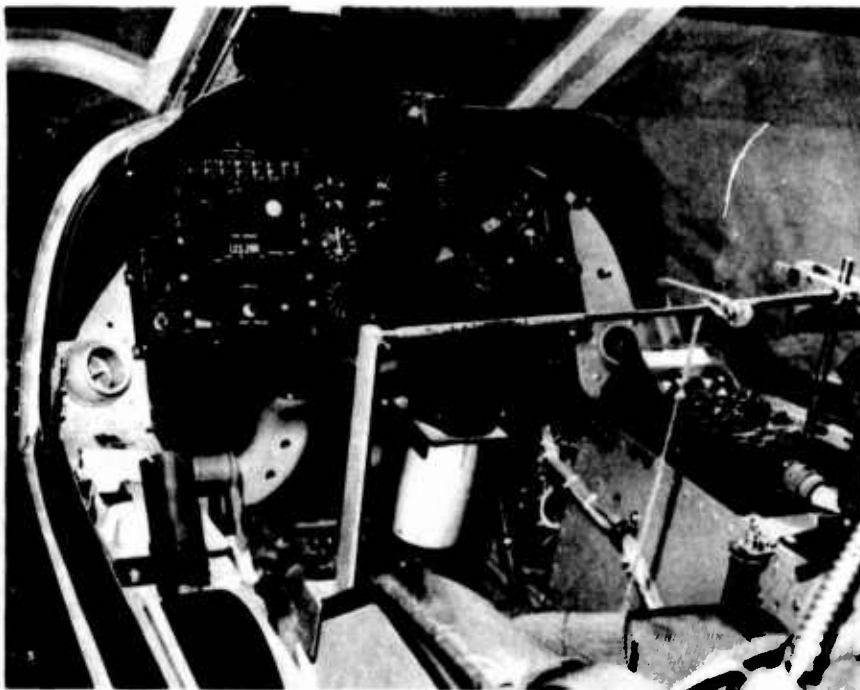


Photo D-3. Forward Cockpit: Control Fixture Set for Lateral Step Input.

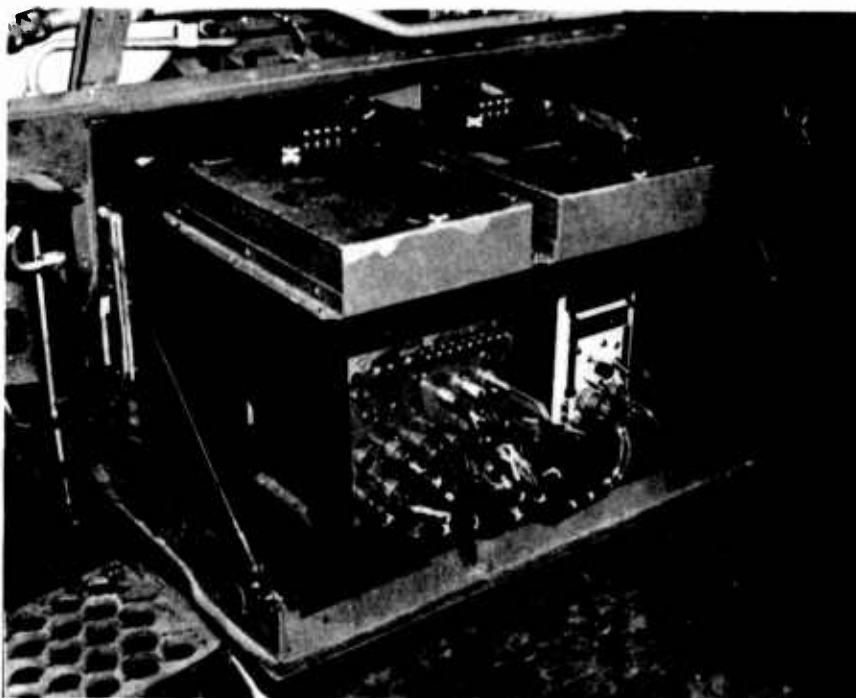


Photo D-4. Ammunition Bay Instrumentation Package.

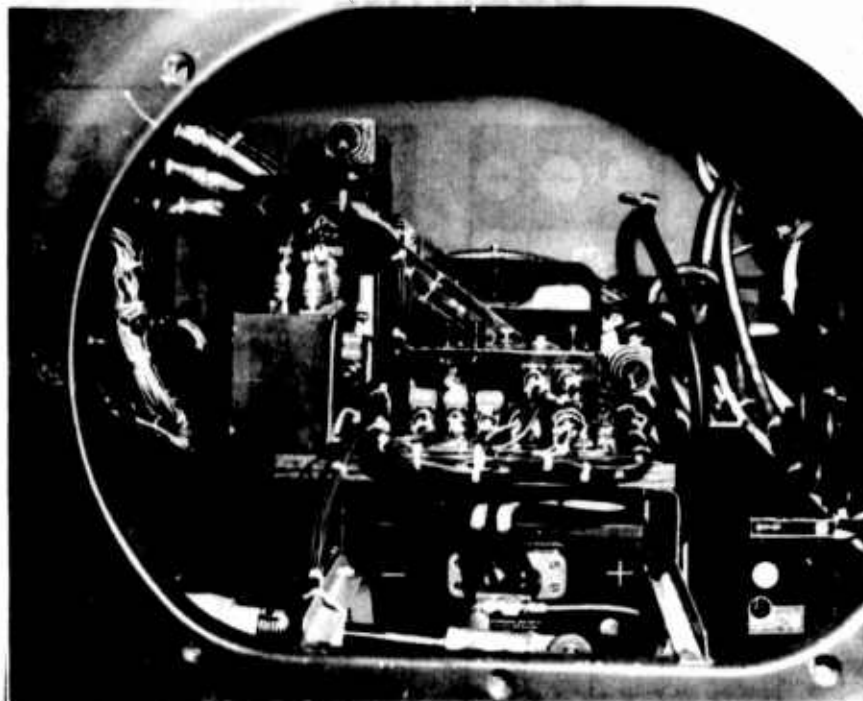
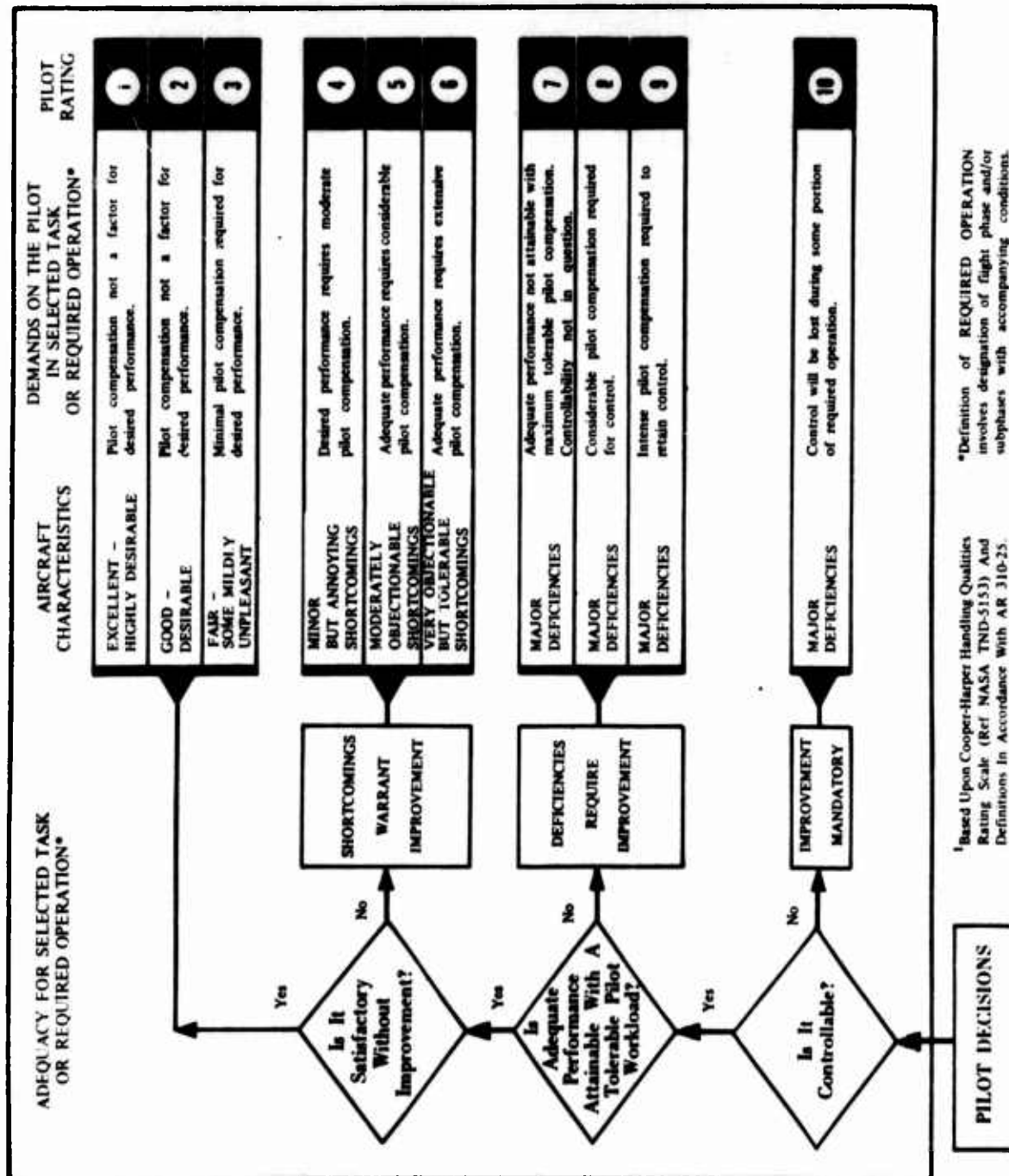


Photo D-5. Gyro Package, Tail Boom.



Photo D-6. Tail Boom Video Tape and High-Speed Camera Mounting.

APPENDIX E. HANDLING QUALITIES RATING SCALE



APPENDIX F. TEST DATA

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Figure 1
Cyclic Stick Control Pattern
AH-1G USA SN 70-10019

- NOTE: 1. AFTER START
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED
BY GROUND POWER UNITS
3. NO 1 AND NO 2 BOOST SYSTEMS ON
4. TOTAL LONGITUDINAL CONTROL TRAVEL 8 IN
5. TOTAL LATERAL CONTROL TRAVEL 8 IN
6. COLLECTIVE CONTROL POSITION DID NOT AFFECT
CYCLIC MOVEMENT LIMITS

LONGITUDINAL CYCLIC STICK POSITION
— IN FROM FULL END

AFT

END

0

2

4

6

8

10

FT

LATERAL CYCLIC STICK POSITION

— IN FROM FULL LEFT

FIGURE 2
 LONGITUDINAL CONTROL FORCE CHARACTERISTICS
 AH-1G USA SN 70-16019

NOTES: 1. ROTOR STATIC

2. FORCES MEASURED AT CENTER OF GRIP

3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS

4. NO LEAD NO 2 BOOST SYSTEM ON

5. 50.10 SYMBOL DENOTES TRIM POINT

6. LATERAL CONTROL POSITION 5.65 INCHES FROM FULL LEFT

7. TOTAL LONGITUDINAL CONTROL

DISPLACEMENT = 9.50 INCHES

8. FORCE TRIM ON

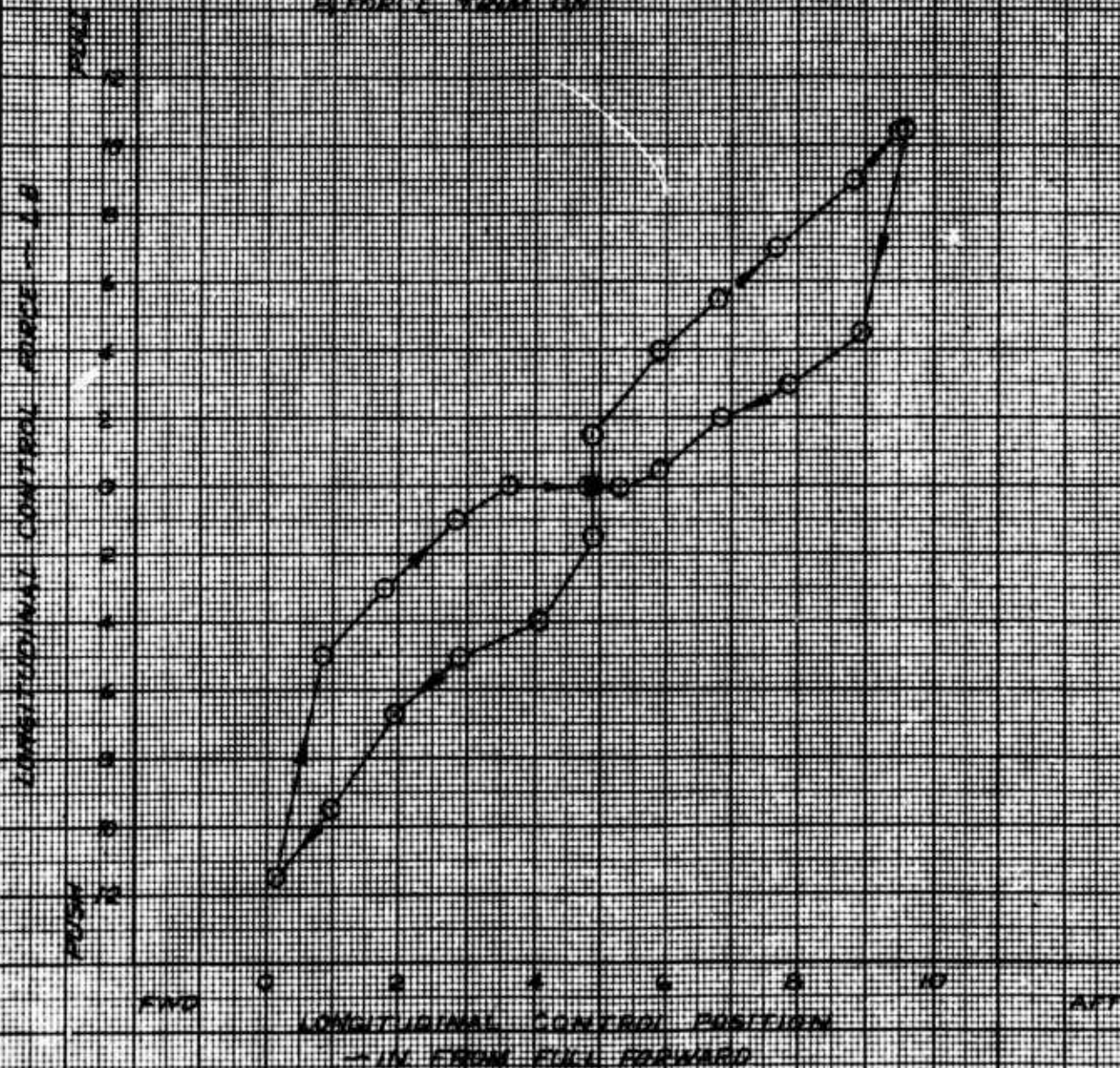


FIGURE 3
Lateral Control System Characteristics
AH-1G USA SIN 70-16019

- NOTES: 1. ROCKET SYSTEM
2. FORCES MEASURED AT CENTER OF GRAVITY
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. NO. 1 AND NO. 2 ROCKET SYSTEMS ON
5. SOLID SYMBOL DENOTES TRIM POINT
6. ADDITIONAL CONTROL POSITION 2.54 INCHES FROM FULL END
7. TOTAL LATERAL CONTROL DISPLACEMENT 9.65 INCHES
8. FORCE TRIM ON

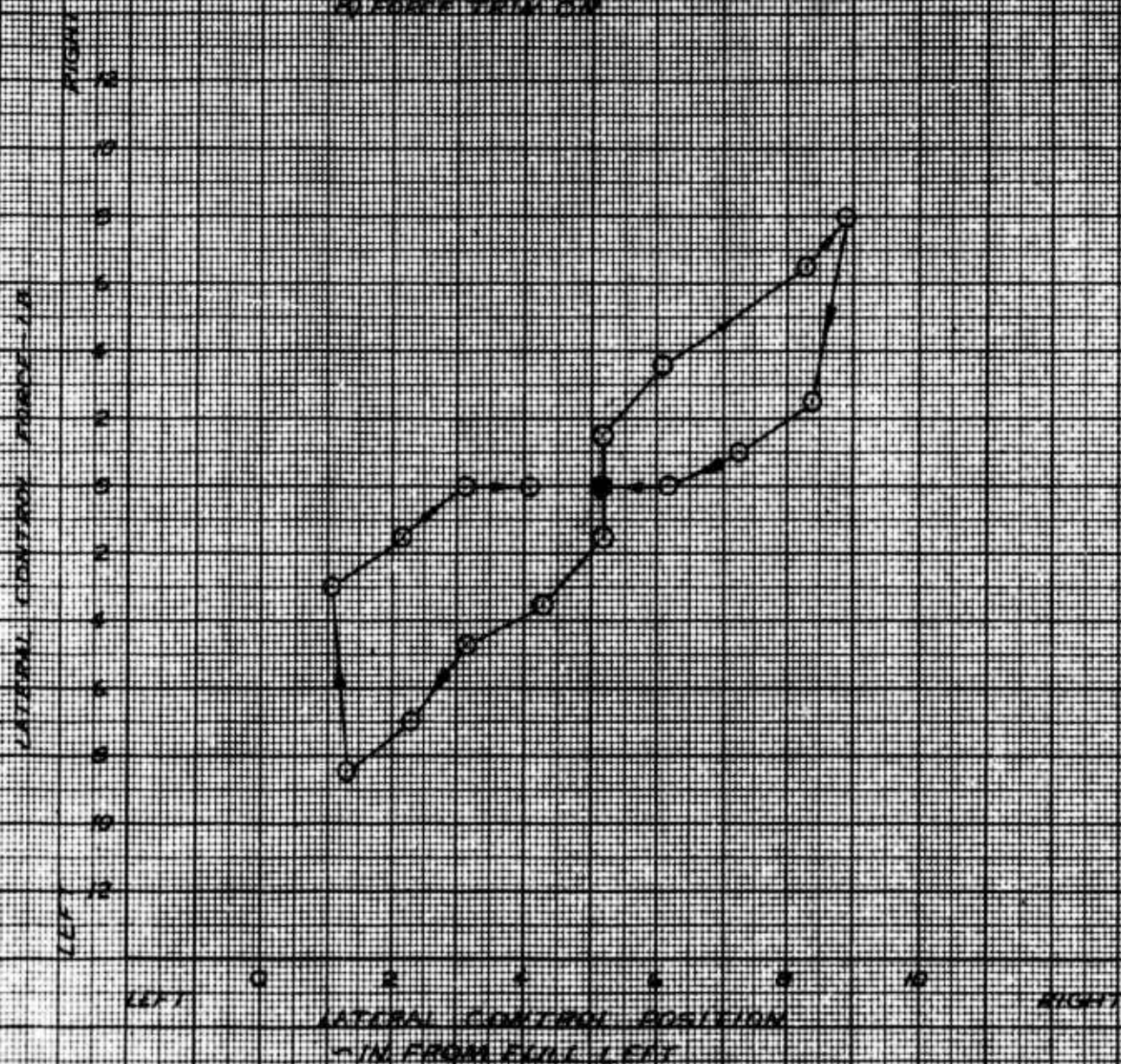


FIGURE 1
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
A-10 USAF 10-1011

NOTES: 1. MOTOR STATIC
2. FORCES MEASURED AT CENTER OF PEDAL
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED
BY GROUND POWER UNIT
4. TOTAL DIRECTIONAL CONTROL DISPLACEMENT
IS 2.5 INCHES

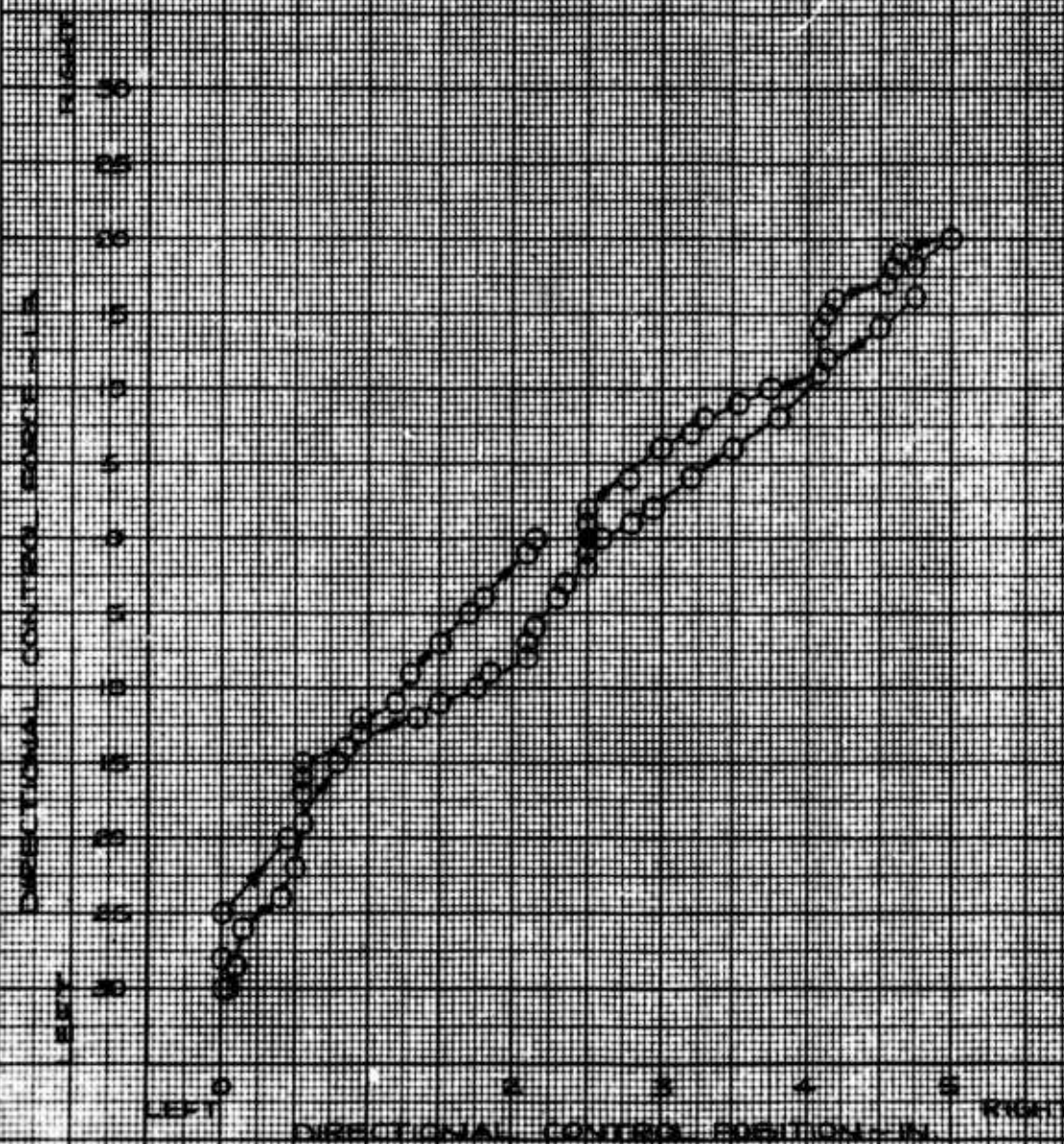
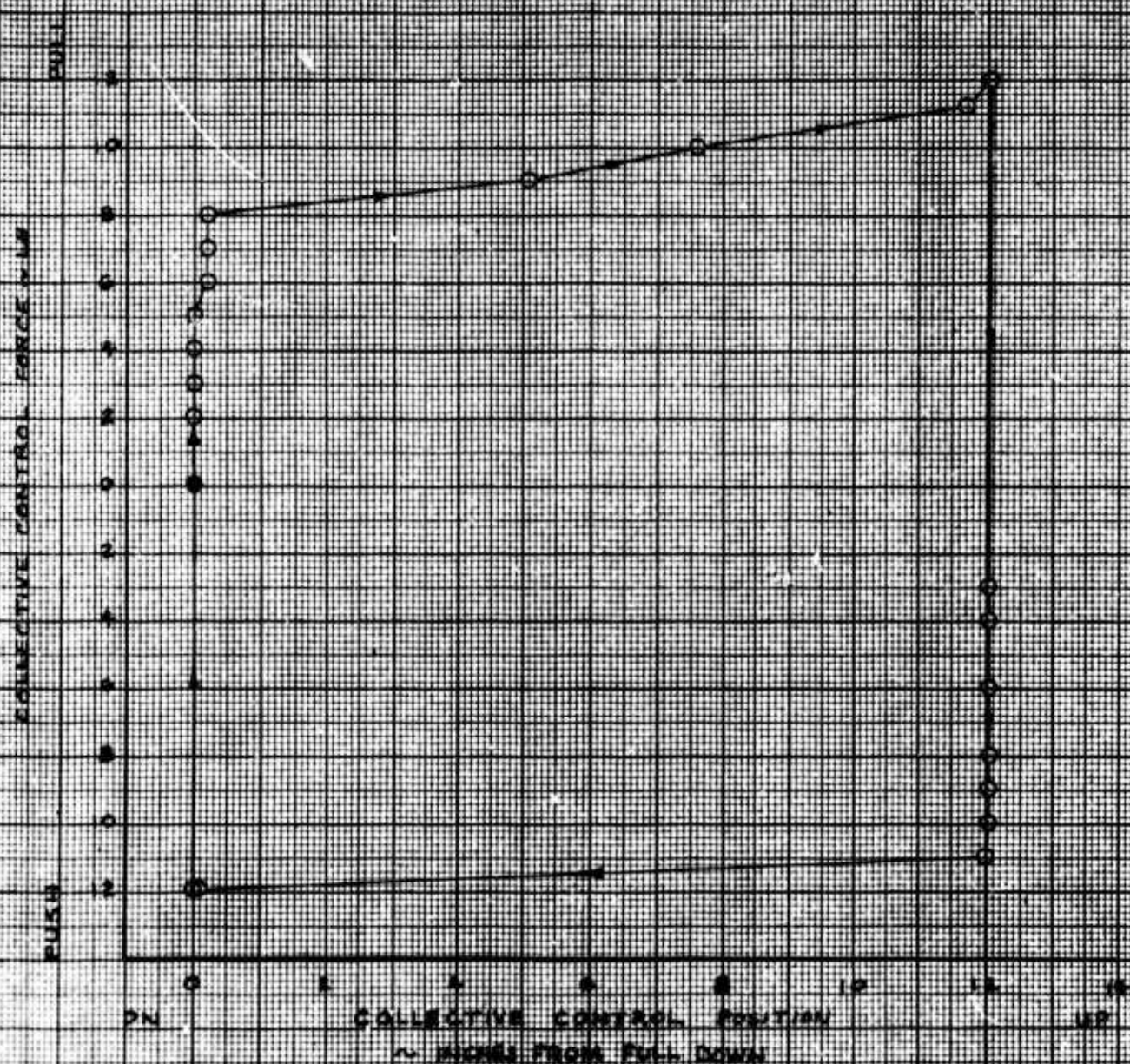


FIGURE 3
COLLECTIVE CONTROL SYSTEM CHARACTERISTICS
AL-10 (SN 571 70-1010)

NOTES: POWER UNIT

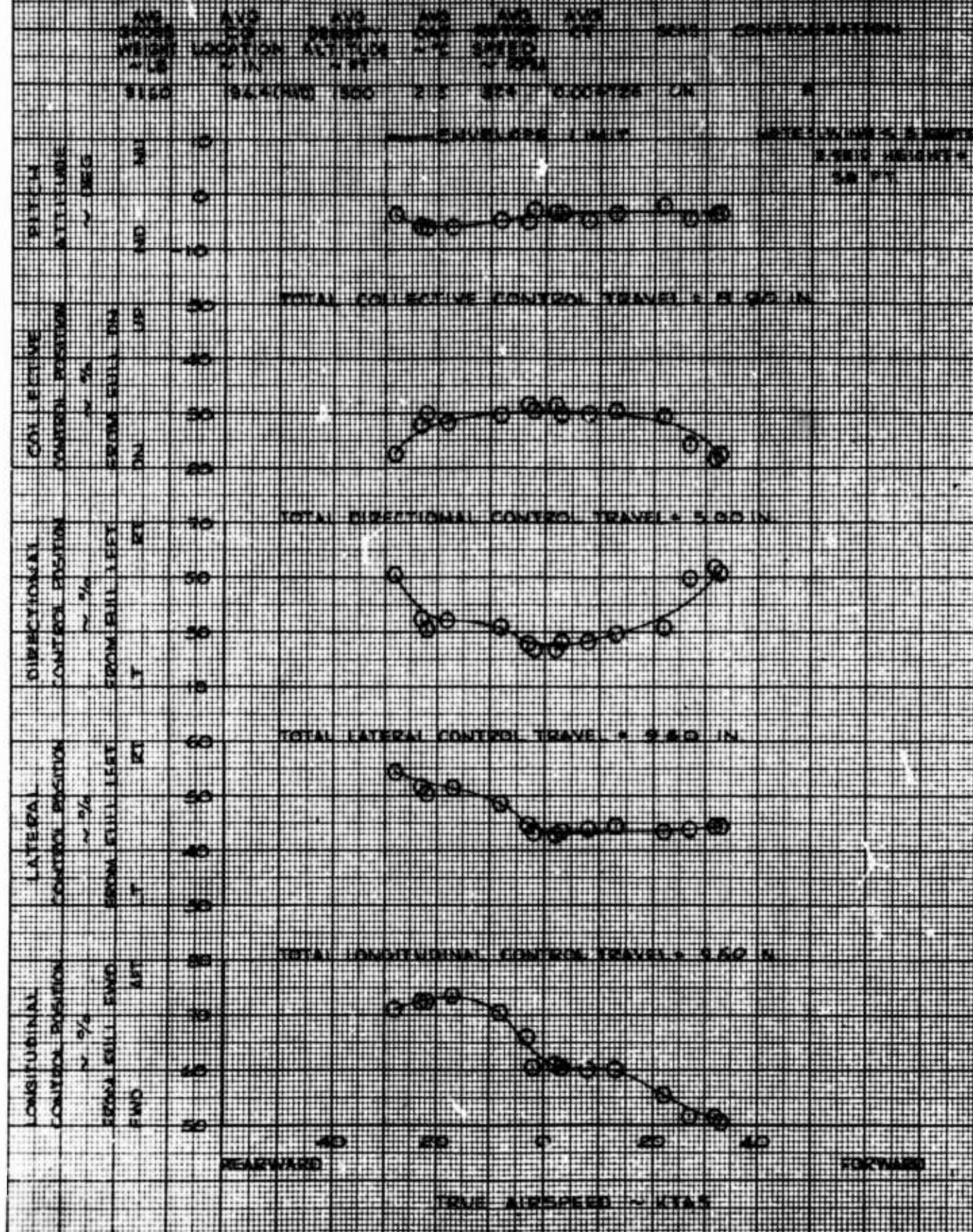
- 1) FORCES MEASURED AT BOTTOM
END OF THROTTLE LINK ROD
- 2) HYDRAULIC AND ELECTRICAL POWER
PROVIDED BY GROUND POWER UNIT
- 3) TOTAL COLLECTIVE CONTROL DISPLACEMENT
IN INCHES (MEASURED AT TOP END OF
SWITCH BOX ASSEMBLY)
- 4) ADJUSTABLE CRUISE ON
- 5) SOLID SYMBOL DENOTES TRIM POINT



THE GREAT ESCAPE



FIGURE 3
CONTROL POSITIONS & DISPLACEMENTS
SLOW SPEED FORWARD FLIGHT
A-10 USA 5/11/70-6018



▲ 1994年10月1日以前に建設された建築物の耐震診断と補修に関する法律（耐震診断法）が施行された。この法律は、建築物の耐震診断と補修に関する事項を定めることにより、建築物の耐震性能の向上を図ることを目的として制定されたものである。この法律に基づき、国土交通省は、建築物の耐震診断と補修に関する技術的基準を定めることとした。この技術的基準は、建築物の耐震診断と補修に関する技術的基準（建築物の耐震診断と補修に関する技術的基準）と称される。この技術的基準は、建築物の耐震診断と補修に関する技術的基準（建築物の耐震診断と補修に関する技術的基準）と称される。

[illegible]

NOTE: SOLID SYMBOLS ARE TERMINALS

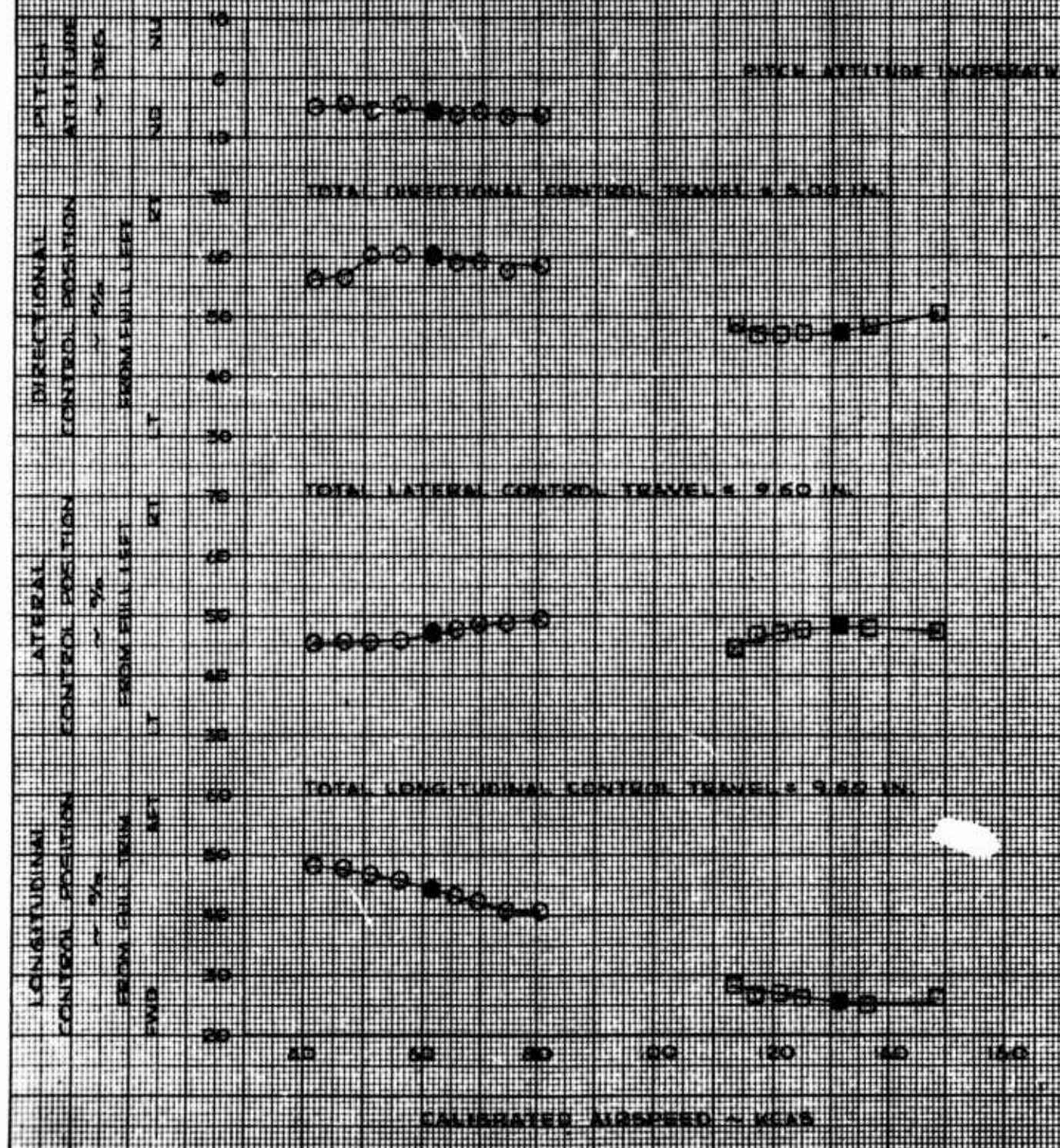


TABLE 2
 SHIP LATERAL DIRECTIONAL STABILITY
 AS TO USA 24 TO 30.9

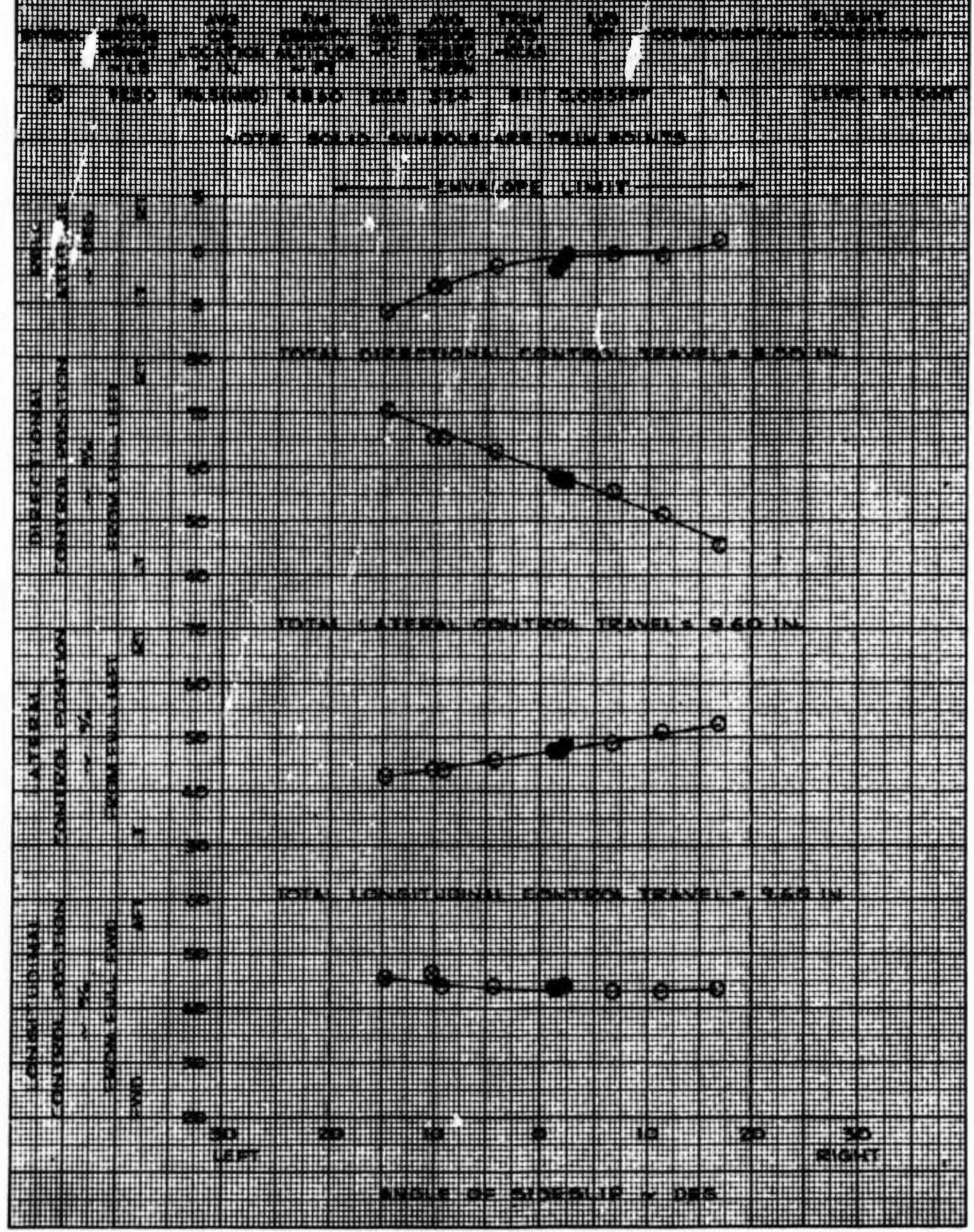


FIGURE 11 BASIC LATERAL DIRECTIONAL SENSITIVITY A4-12 USA CAN YO-20'S

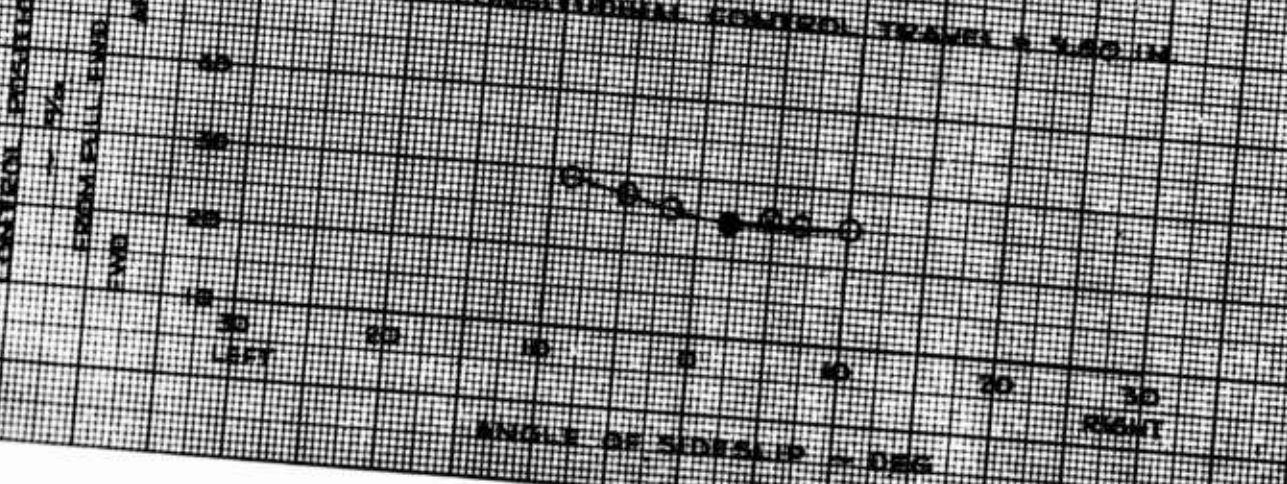
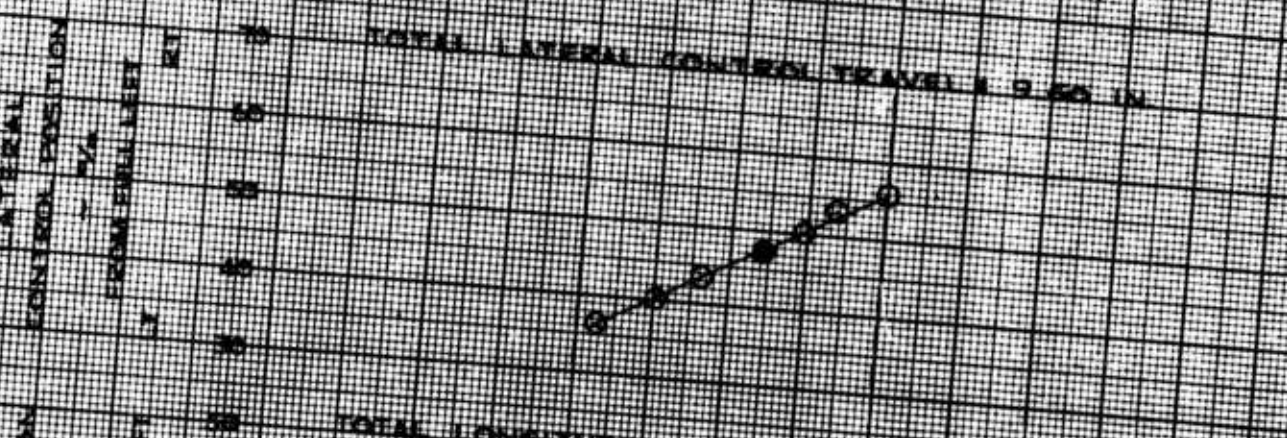
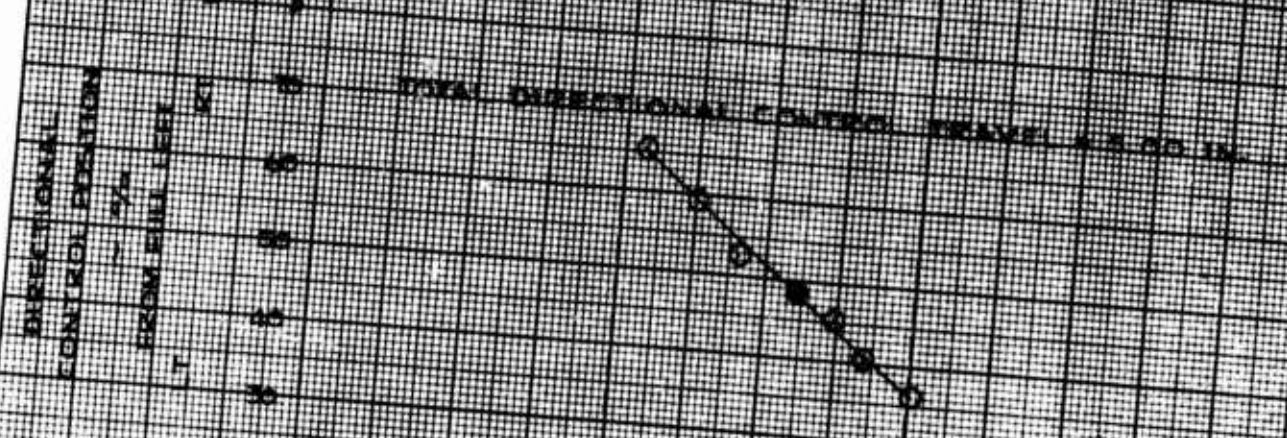
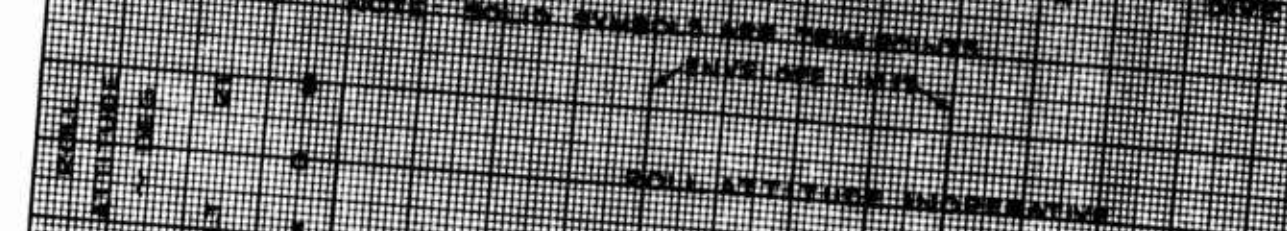
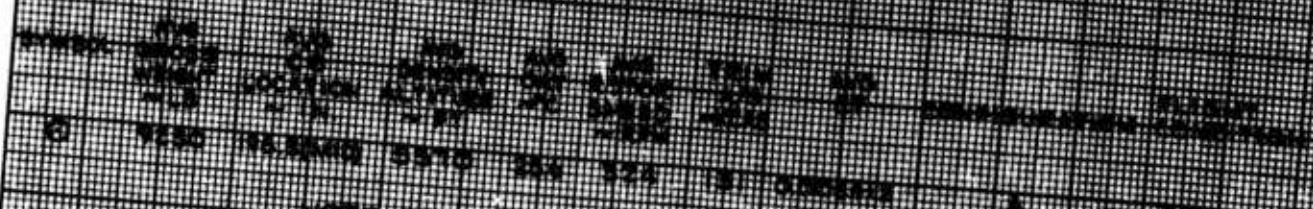


FIGURE 12
AFT LONGITUDINAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT - LB	AVG CG LOCATION - IN.	AVG DENSITY ALTITUDE - FT	AVG OAT - °C	AVG ROTOR SPEED - RPM	TRIM AIRSPEED - KCAS	AVG CT	SCAS CONFIGURATION
9240	196.1(MID)	6040	19.5	324	131	0.003496	ON A

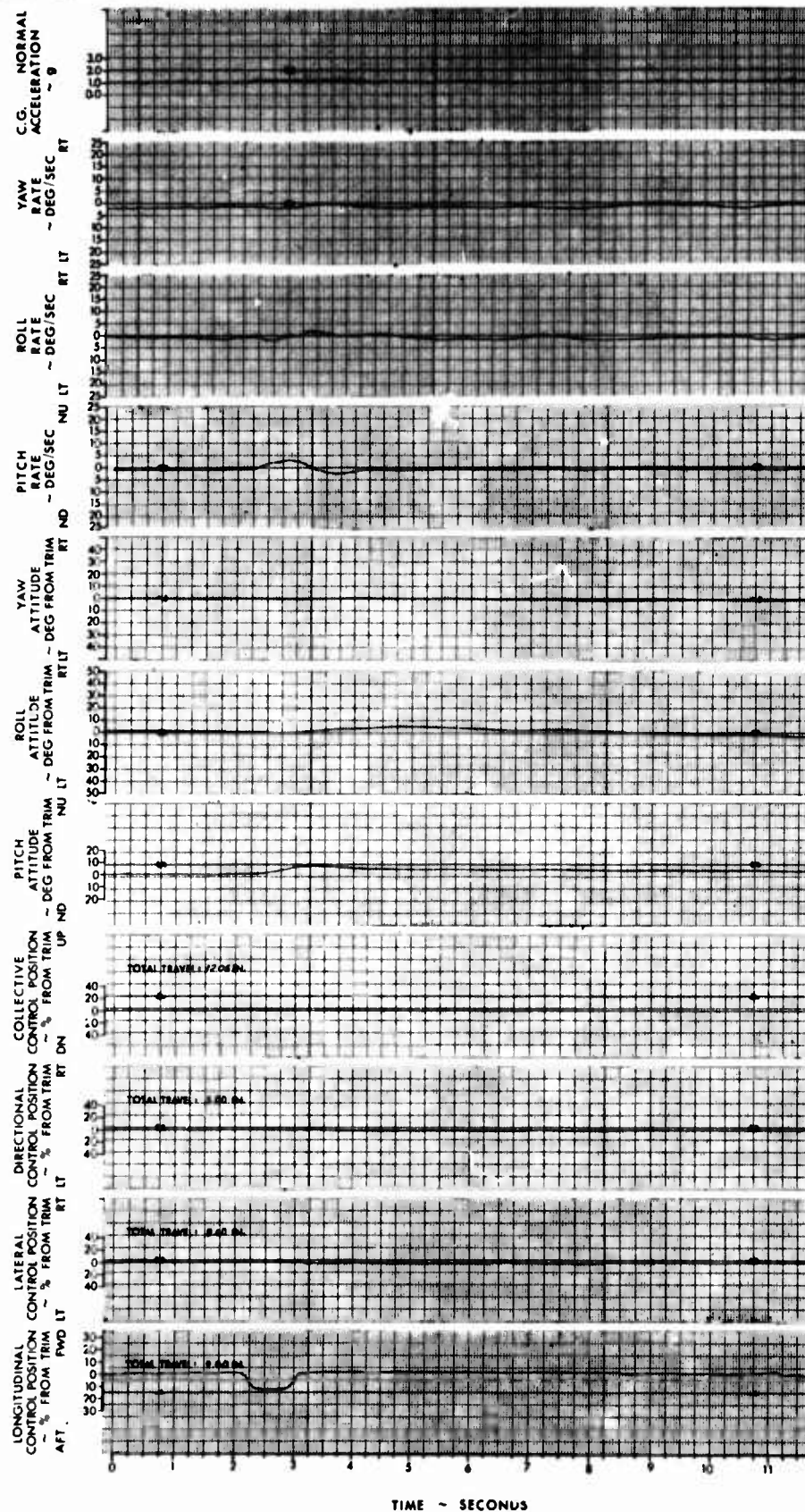
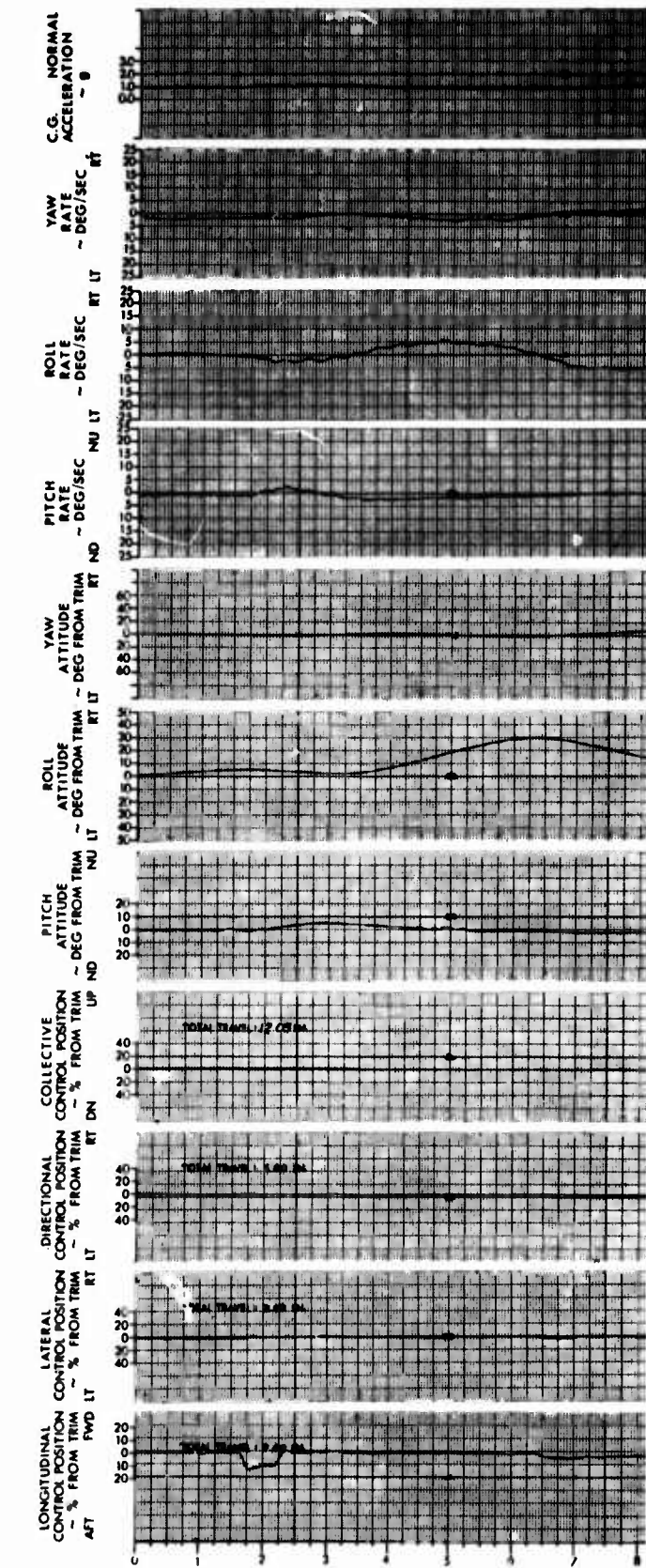


FIGURE 13
AFT LONGITUDINAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT - LB	AVG CG LOCATION - IN.	AVG DENSITY ALTITUDE - FT	AVG OAT - °C	AVG ROTOR SPEED - RPM	TRIM AIRSPEED - KCAS	AVG CT	SCAS CONFIGURATION
9340	196.2(MID)	5050	21.5	324	131	0.005391	OFF A



TIME - SECONDS

FIGURE M
RIGHT LATERAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT - LB	AVG CG LOCATION - IN.	AVG DENSITY ALTITUDE - FT	AVG OAT - °C	AVG ROTOR SPEED - RPM	TRIM AIRSPEED - KCAS	AVG CT	SCAS	CONFIGURATION
9240	196.1(MID)	6040	19.5	324	131	0.003496	ON	A

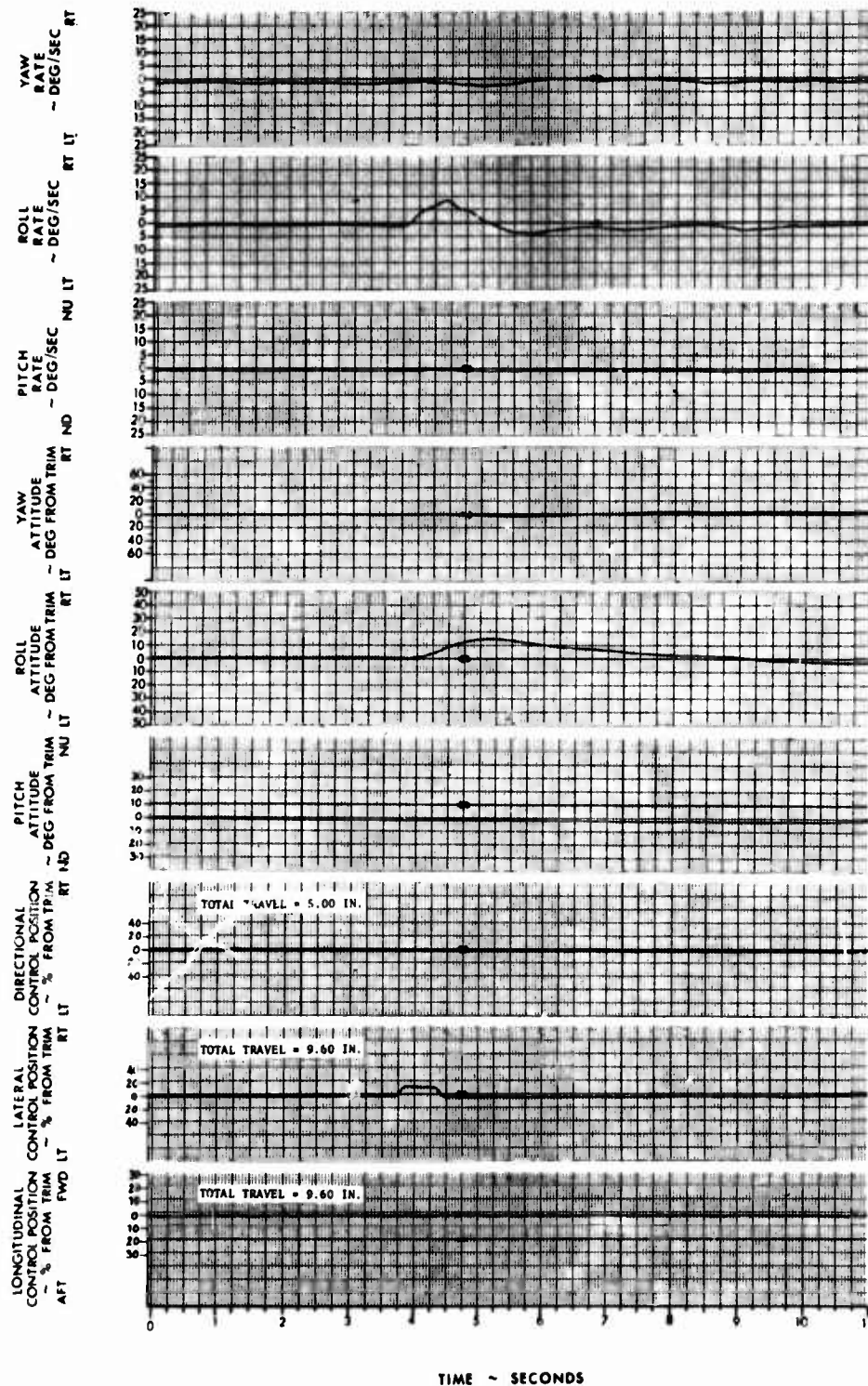


FIGURE 15
RIGHT LATERAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	TRIM AIRSPEED ~ KCAS	AVG CT	SCAS CONFIGURATION
9340	196.2 (MID)	5050	21.5	324	131	0.005391	OFF A

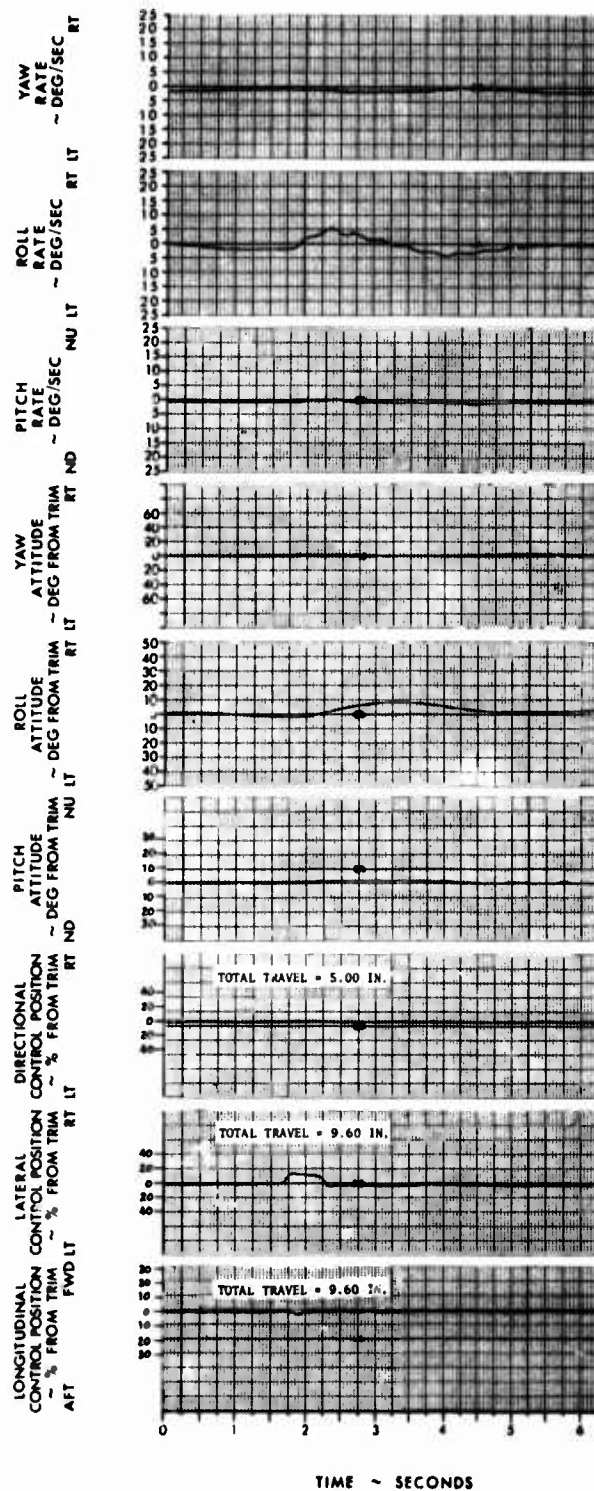


FIGURE 16
RIGHT DIRECTIONAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	TRIM AIRSPEED ~ KCAS	AVG CT	SCAS CONFIGURATION
9240	196.1(MID)	6040	19.5	324	131	0.005496	ON A

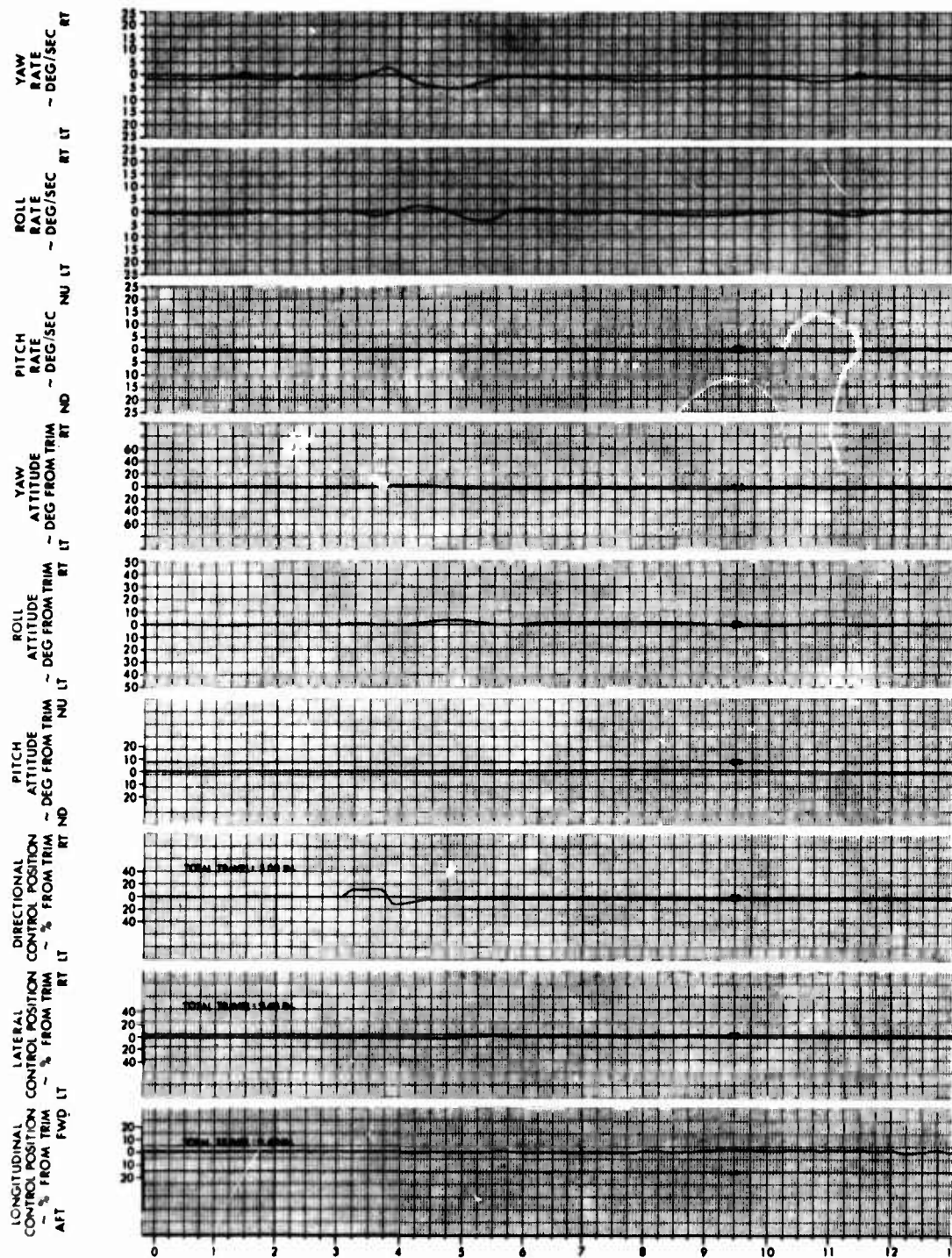
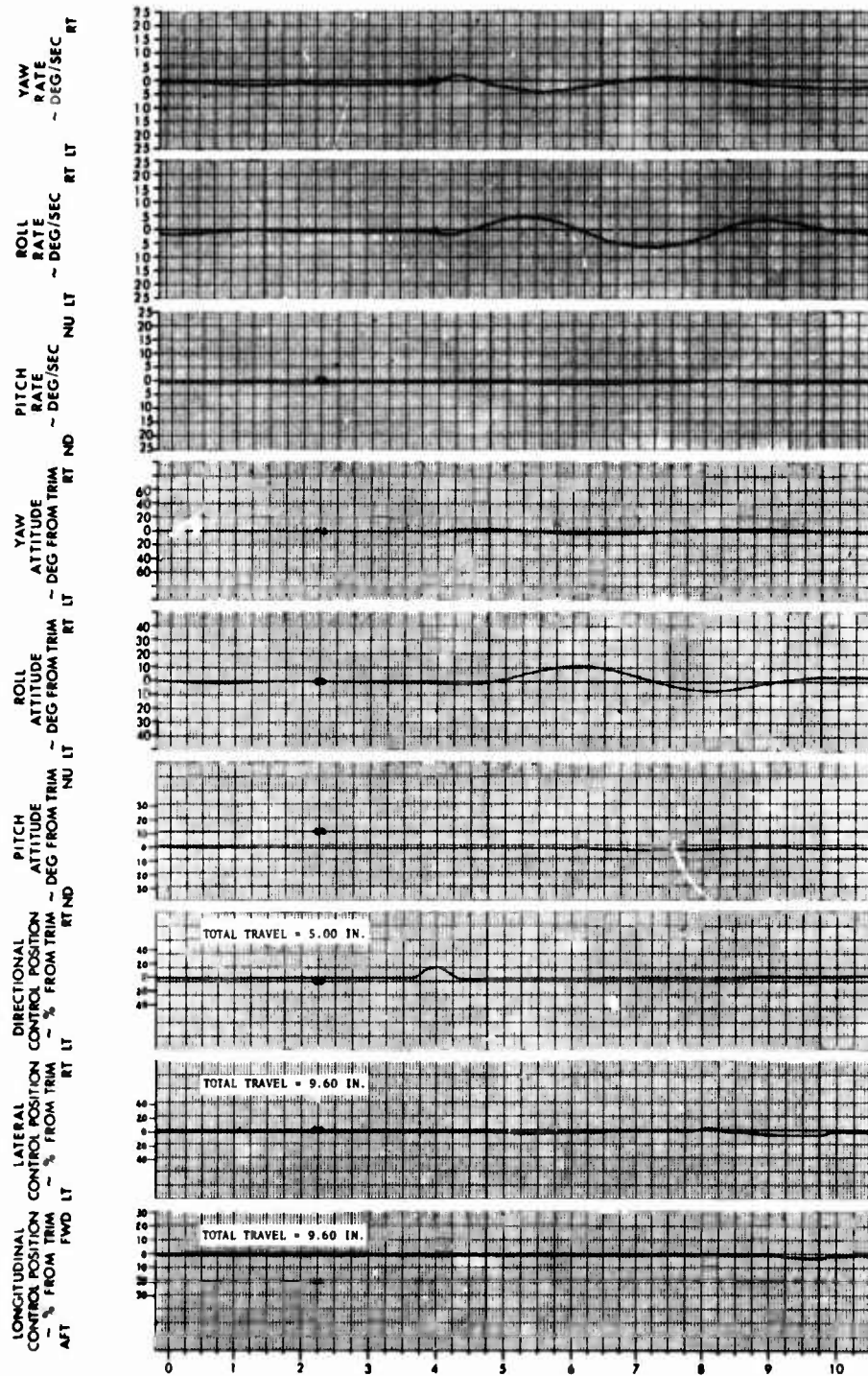


FIGURE 17
RIGHT DIRECTIONAL PULSE
AH-1Q USA S/N 70-16019

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	TRIM AIRSPEED ~ KCAS	AVG CT	SCAS CONFIGURATION
9340	196.2(MID)	5050	21.5	324	131	0.003391	OFF A



TIME ~ SECONDS

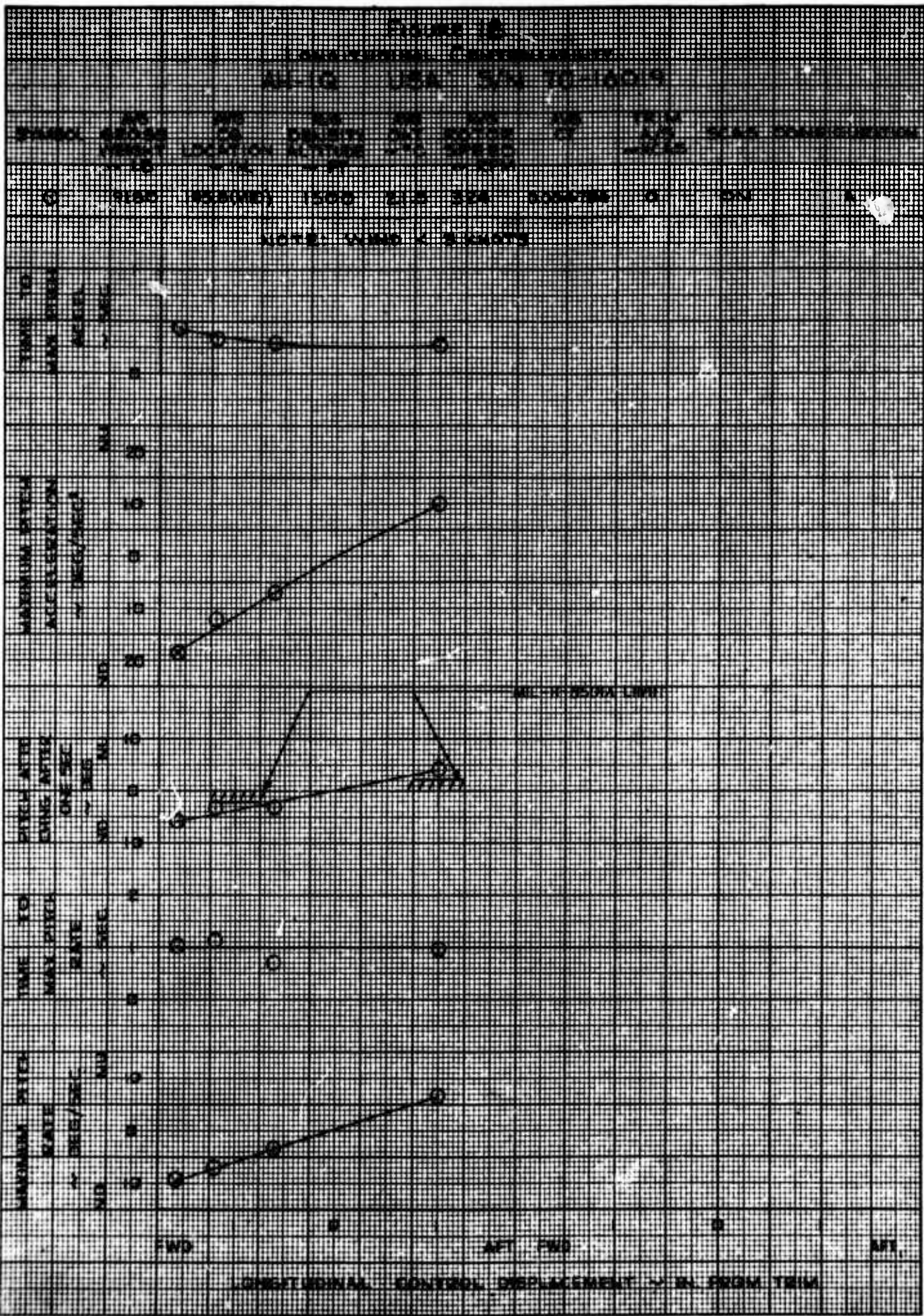
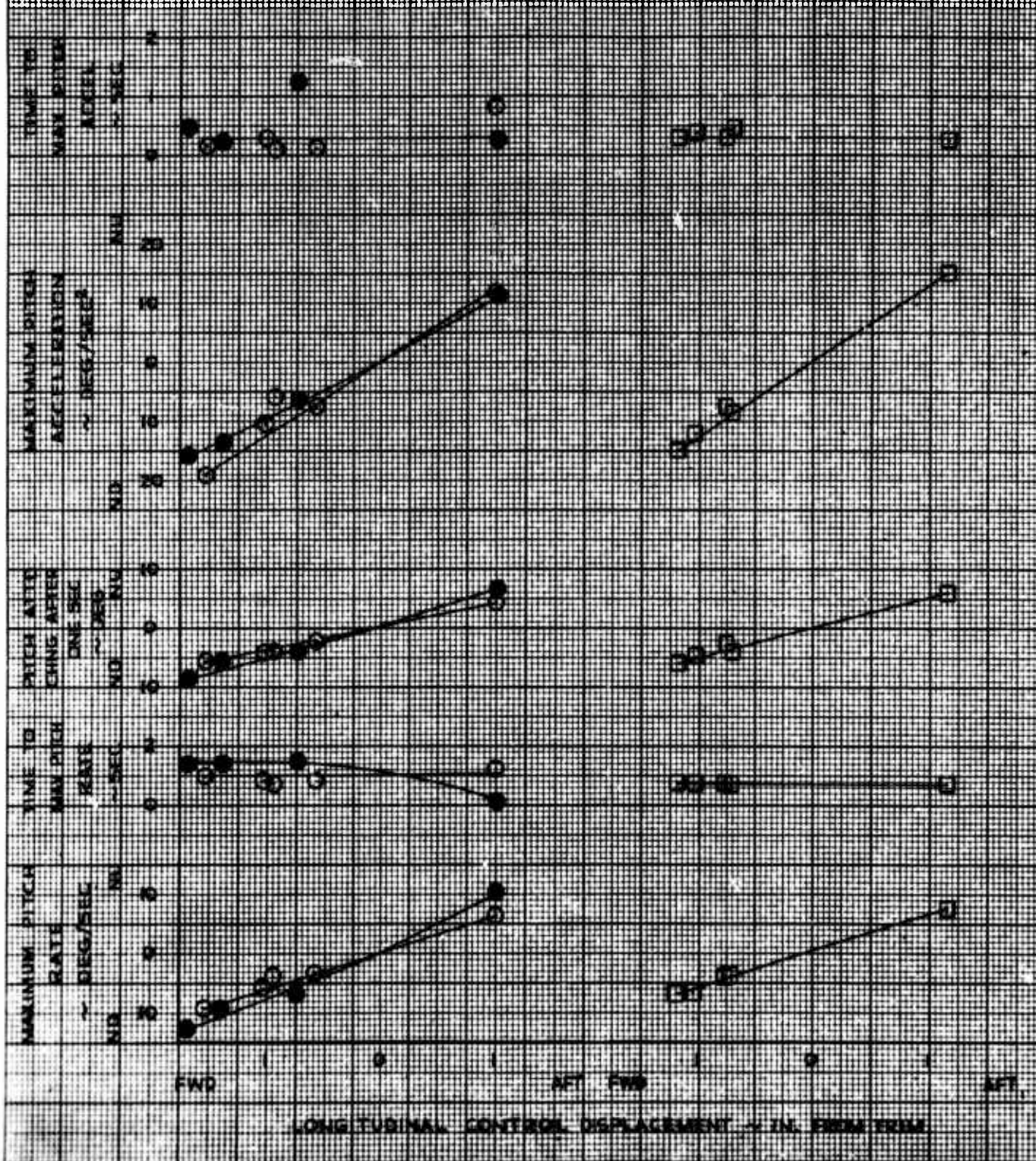


Figure 18
Longitudinal Control Limits
Alt 10,000 ft S/N 10-11019

Series	Altitude Feet	Location Lat/Lon	Altitude Feet	Altitude Feet	Altitude Feet	Altitude Feet	Altitude Feet	Altitude Feet	Altitude Feet
1	10000	1000000	10000	10000	10000	10000	10000	10000	10000
2	10000	1000000	10000	10000	10000	10000	10000	10000	10000
3	10000	1000000	10000	10000	10000	10000	10000	10000	10000



[illegible]

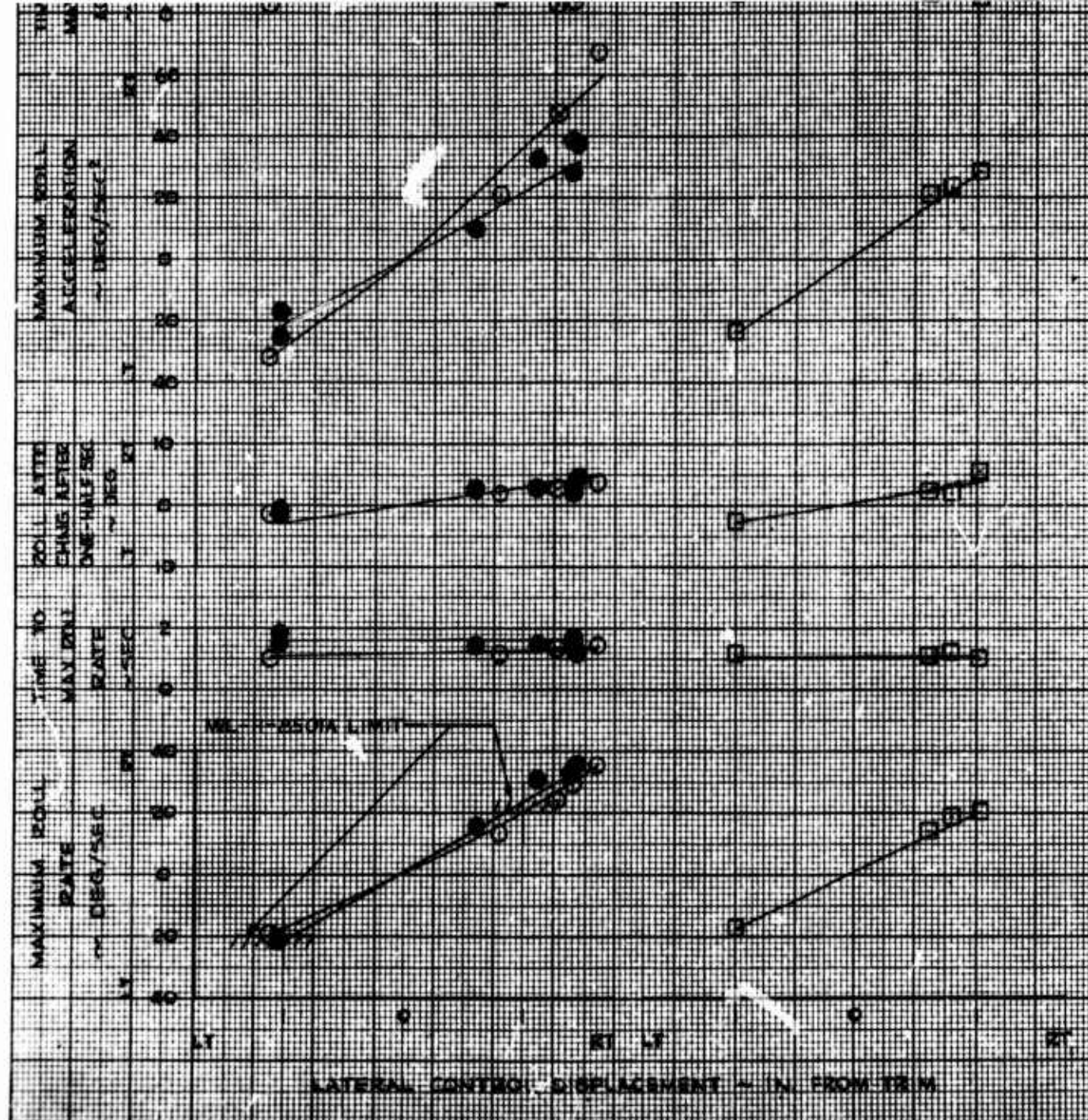
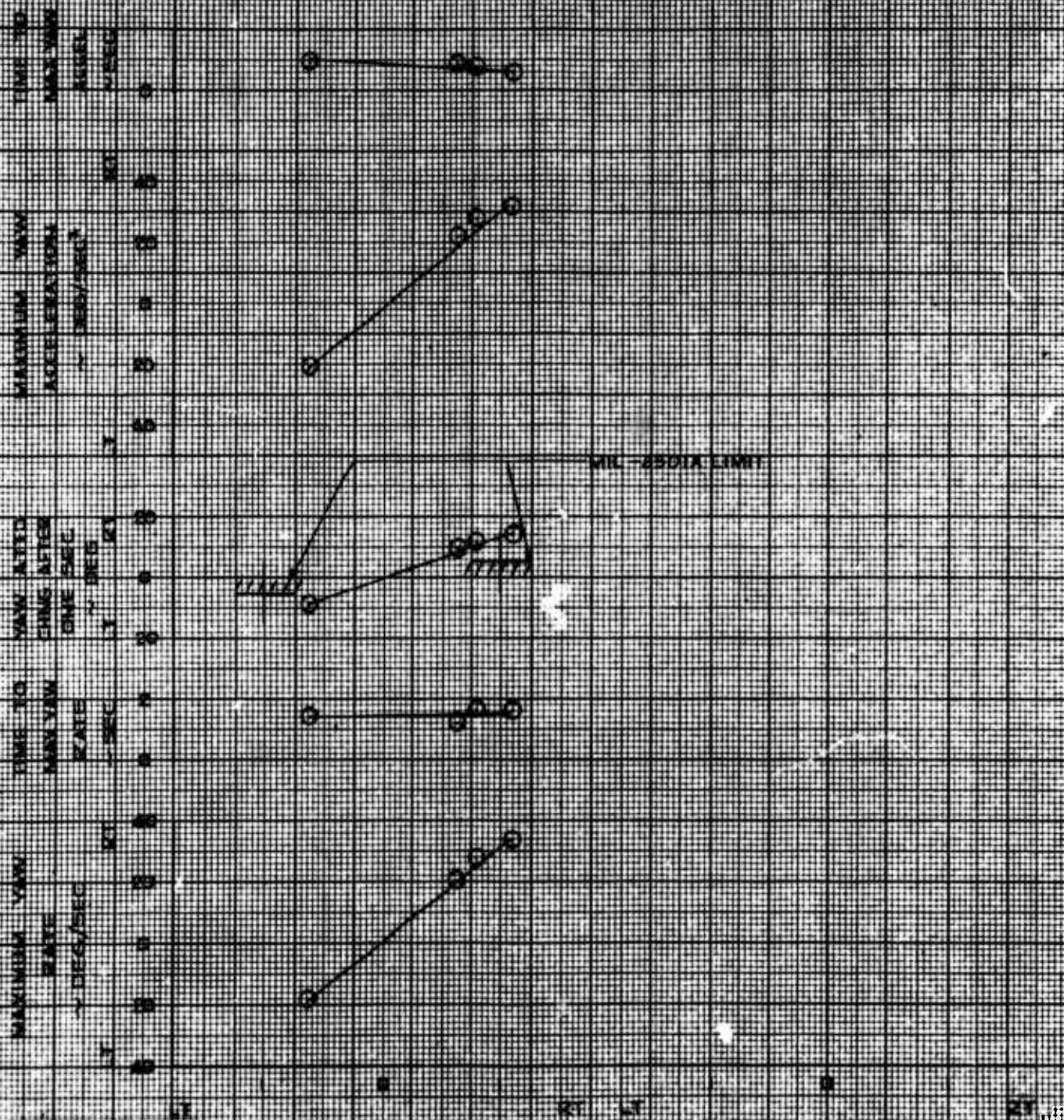


FIGURE 23
Directional Control
AH-1G USA SN 70-16019

SYMBOL	ALT VALU	LOC LOCATION	REV REV	ALT VALU	LOC LOCATION	REV REV	ALT VALU	LOC LOCATION	REV REV
1	1100	1100	1100	1100	1100	1100	1100	1100	1100

NOTE: WIND 4-5 KNOTS



DIRECTIONAL CONTROL DISPLACEMENT IN PERIOD

TABLE 23
Directional Characteristics
A-10 USA SN 70-16019

PARAMETER	ASR CRUISE MODE	ASR CLIMAX MODE	ASR MAXIMUM ALTITUDE MODE	ASR CLIMAX MODE	ASR CLIMAX MODE	ASR CLIMAX MODE	ASR CLIMAX MODE	ASR CLIMAX MODE	ASR CLIMAX MODE
0	9370	9510	9150	9000	9000	9000	9000	9000	A
1	9300	9500	9020	8900	8900	8900	8900	8900	A
2	9200	9400	8900	8800	8800	8800	8800	8800	A

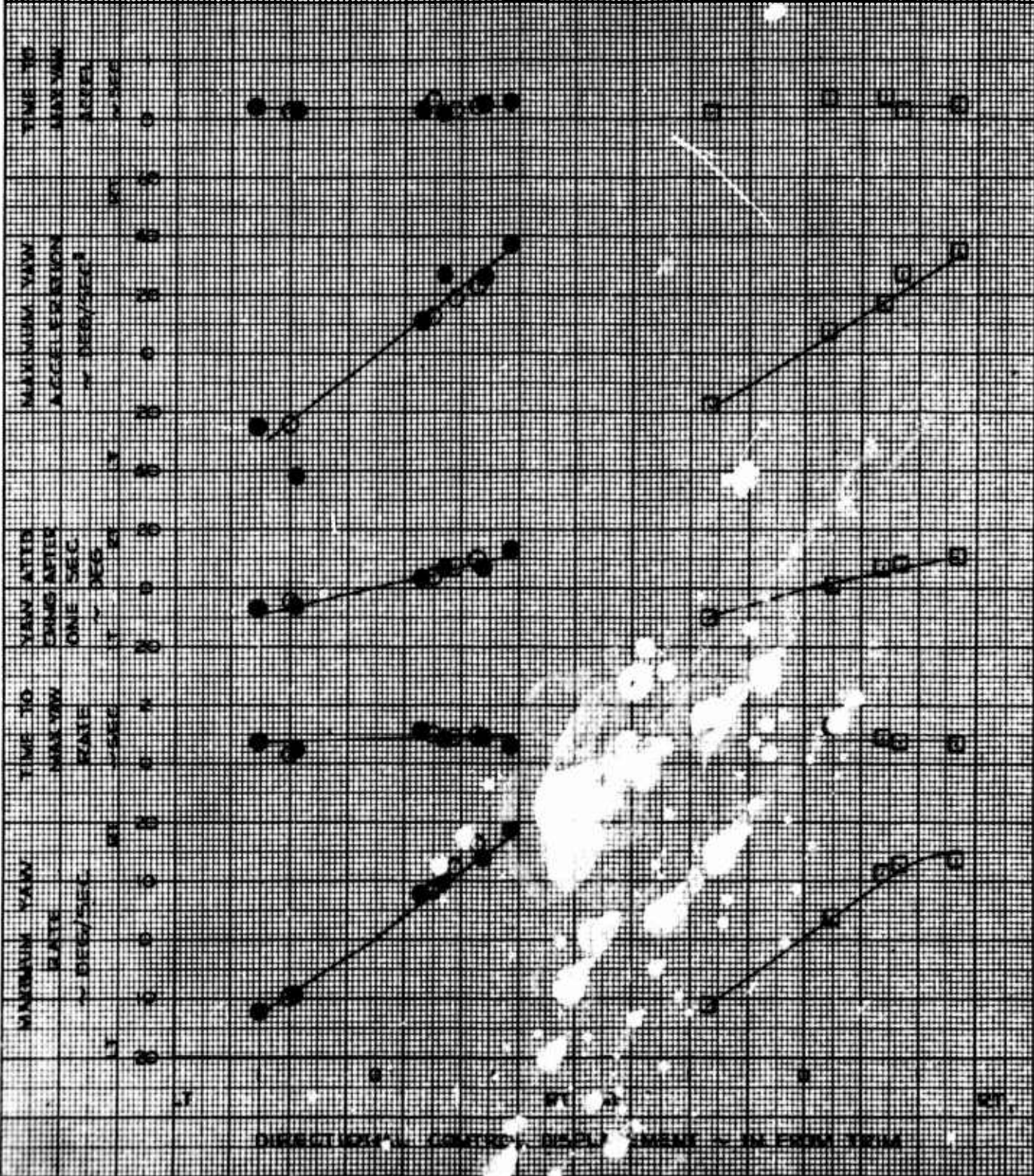


TABLE 24 MANEUVERING CHARACTERISTICS AT 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100 KNOTS

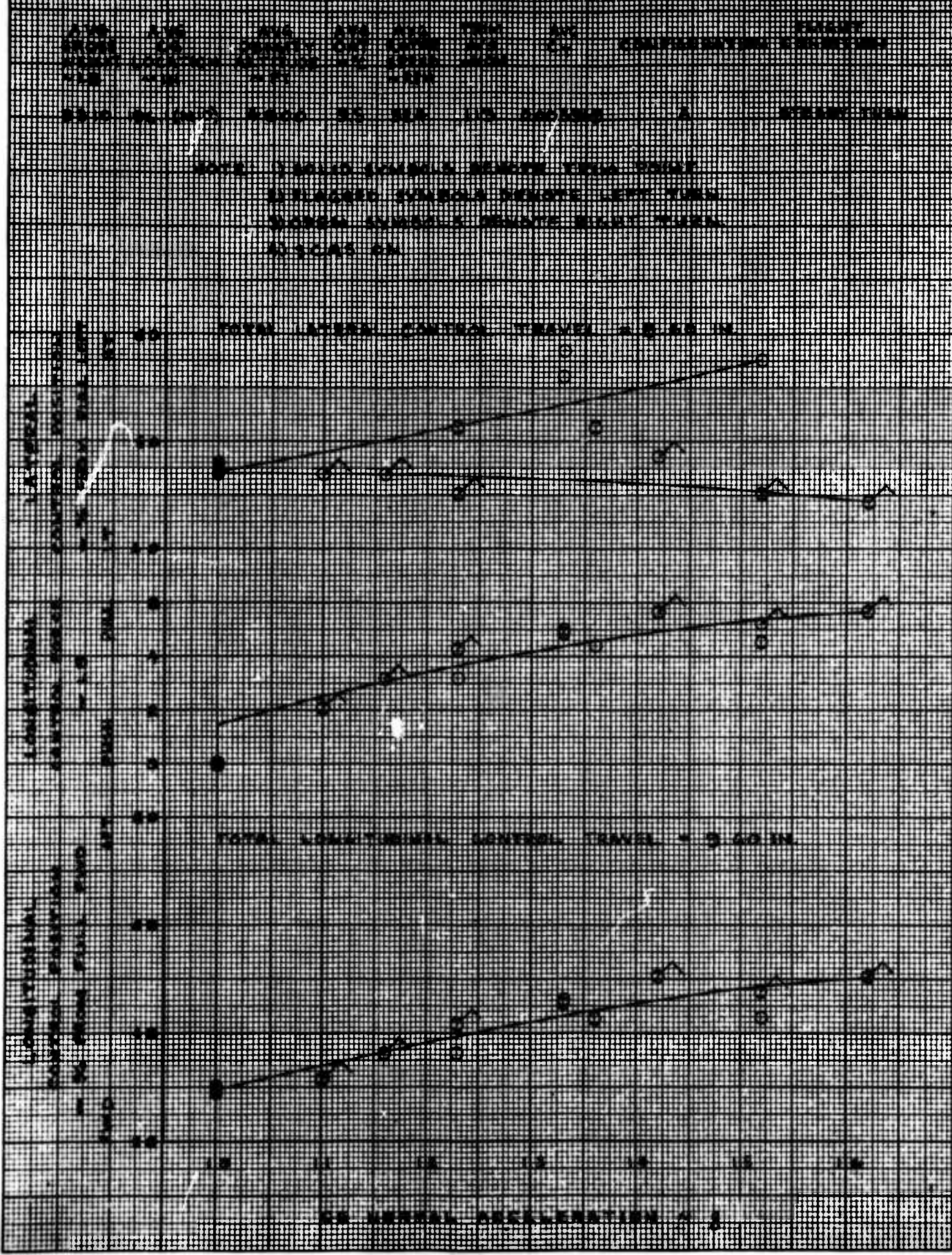


FIGURE 25
SIMULATED ENGINE FAILURE
AH-1Q USA S/N 70-16019

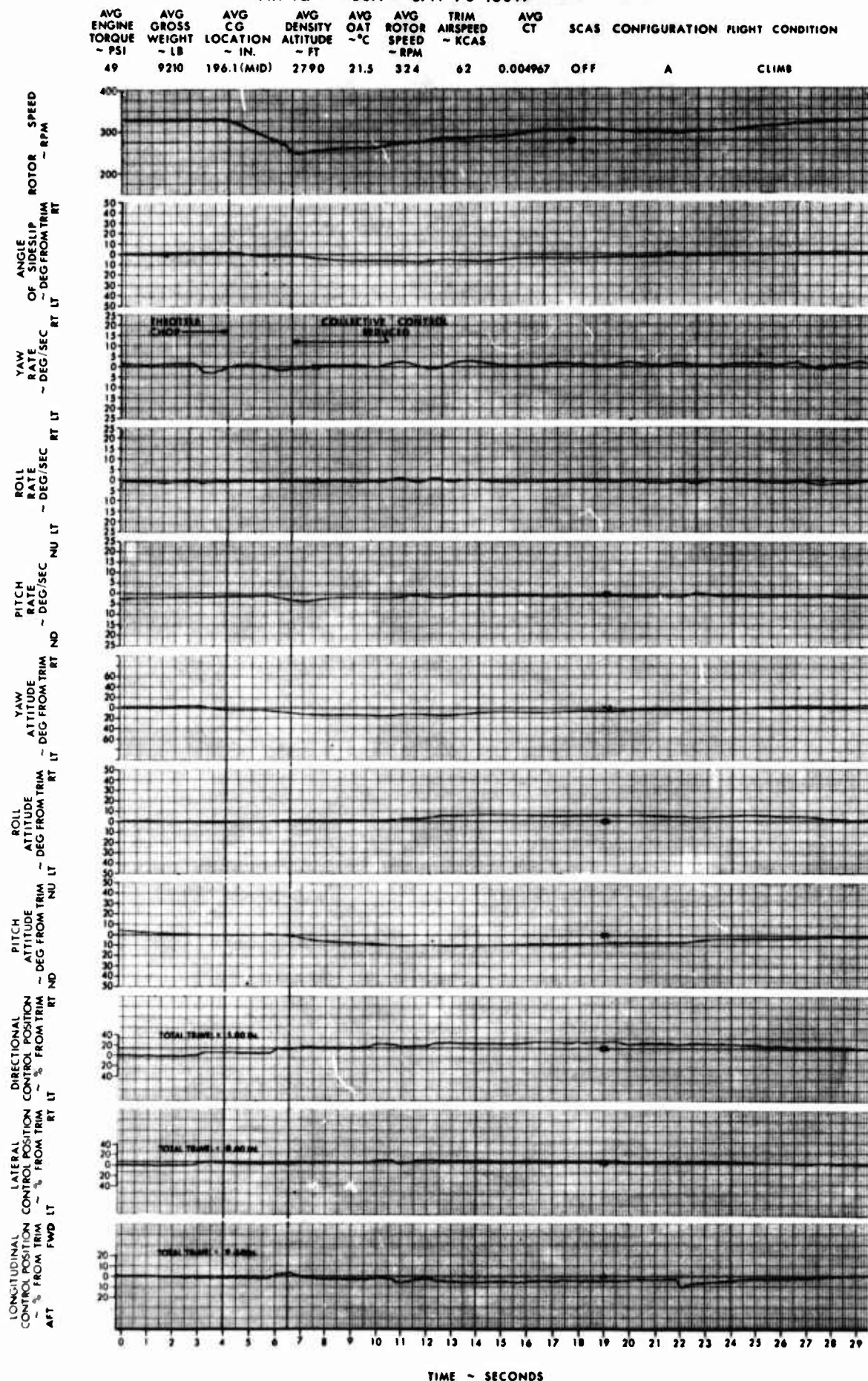


FIGURE 26
SIMULATED ENGINE FAILURE
AH-1Q USA S/N 70-16019

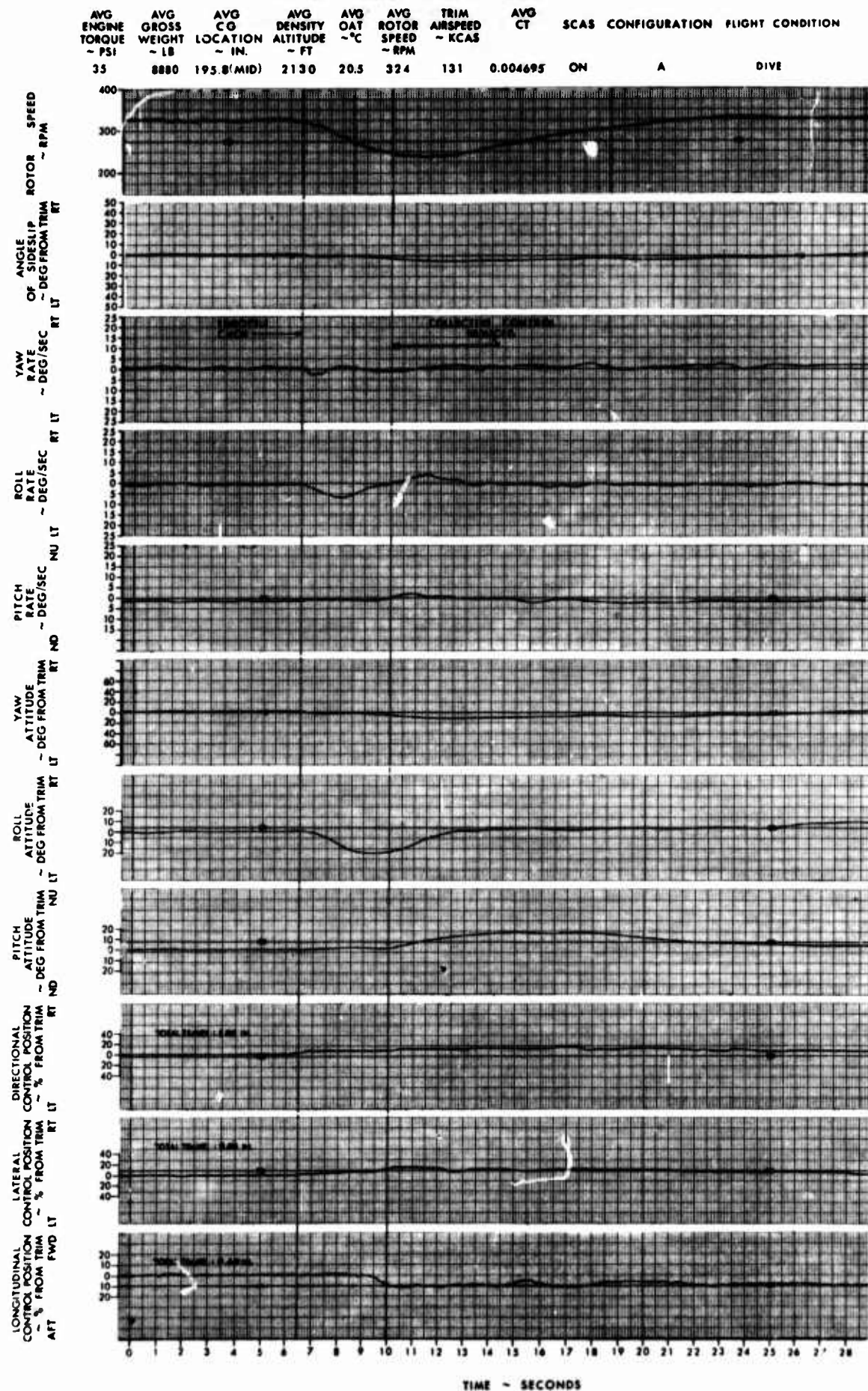


FIGURE 27
SIMULATED ENGINE FAILURE
AH-1Q USA S/N 70-16019

AVG ENGINE TORQUE ~ PSI	AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	TRIM AIRSPEED ~ KCAS	AVG CT	SCAS	CONFIGURATION	FLIGHT CONDITION
35	8880	195.8(MID)	3060	25.5	324	131	0.004695	OFF	A	DIVE

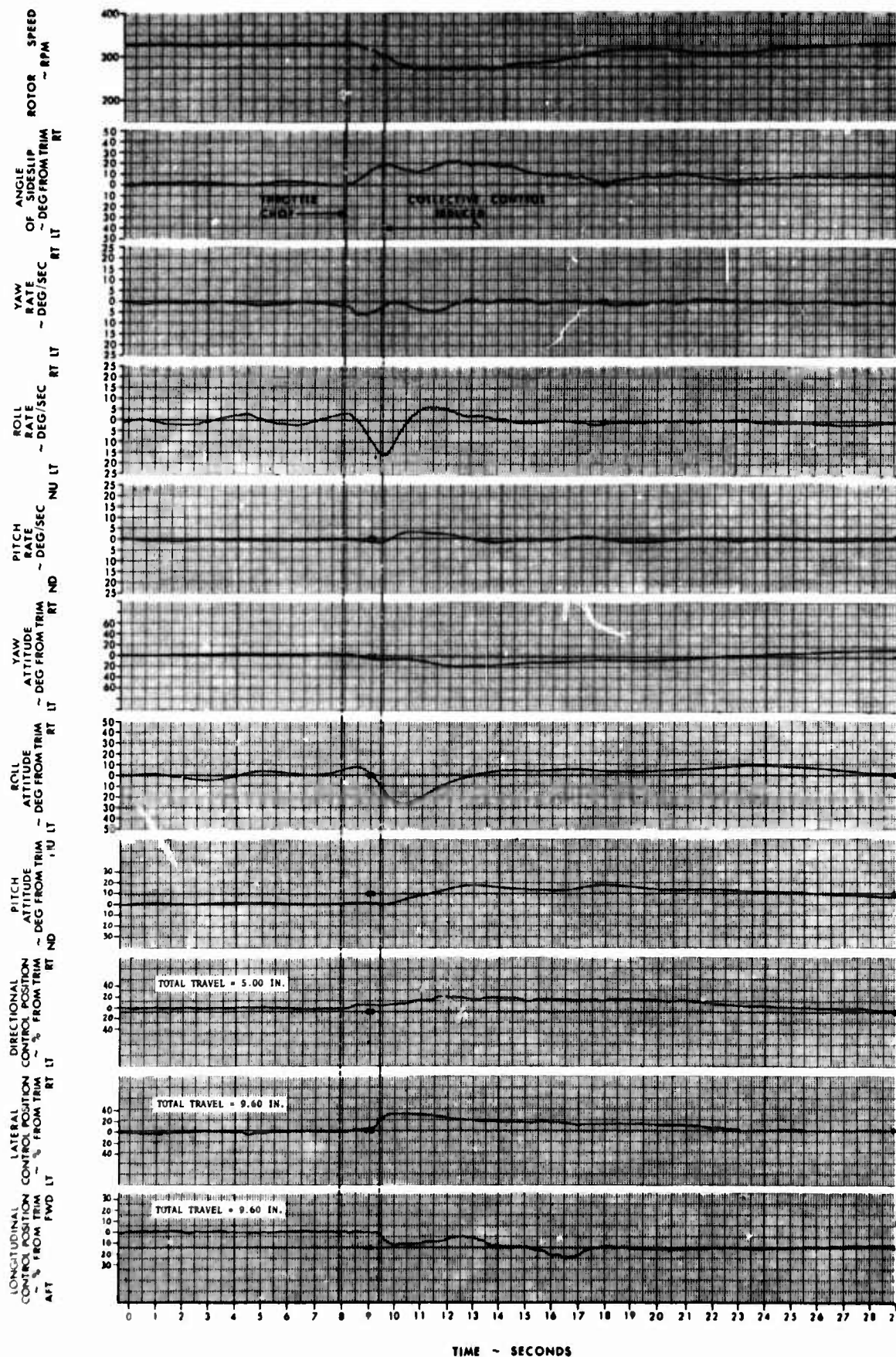


FIGURE 28 VIBRATION CHARACTERISTICS AH-1Q USA S/N 70-16019

C.G. VERTICAL @ FS 196.7 SL - 9.625 WL 69.25

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	AVG CT	SCAS CONFIGURATION	FLIGHT CONDITION
9230	196.3(MID)	5570	25.5	324	0.005412	ON A	1.45g SYMMETRICAL PULL UP AT 130 KCAS

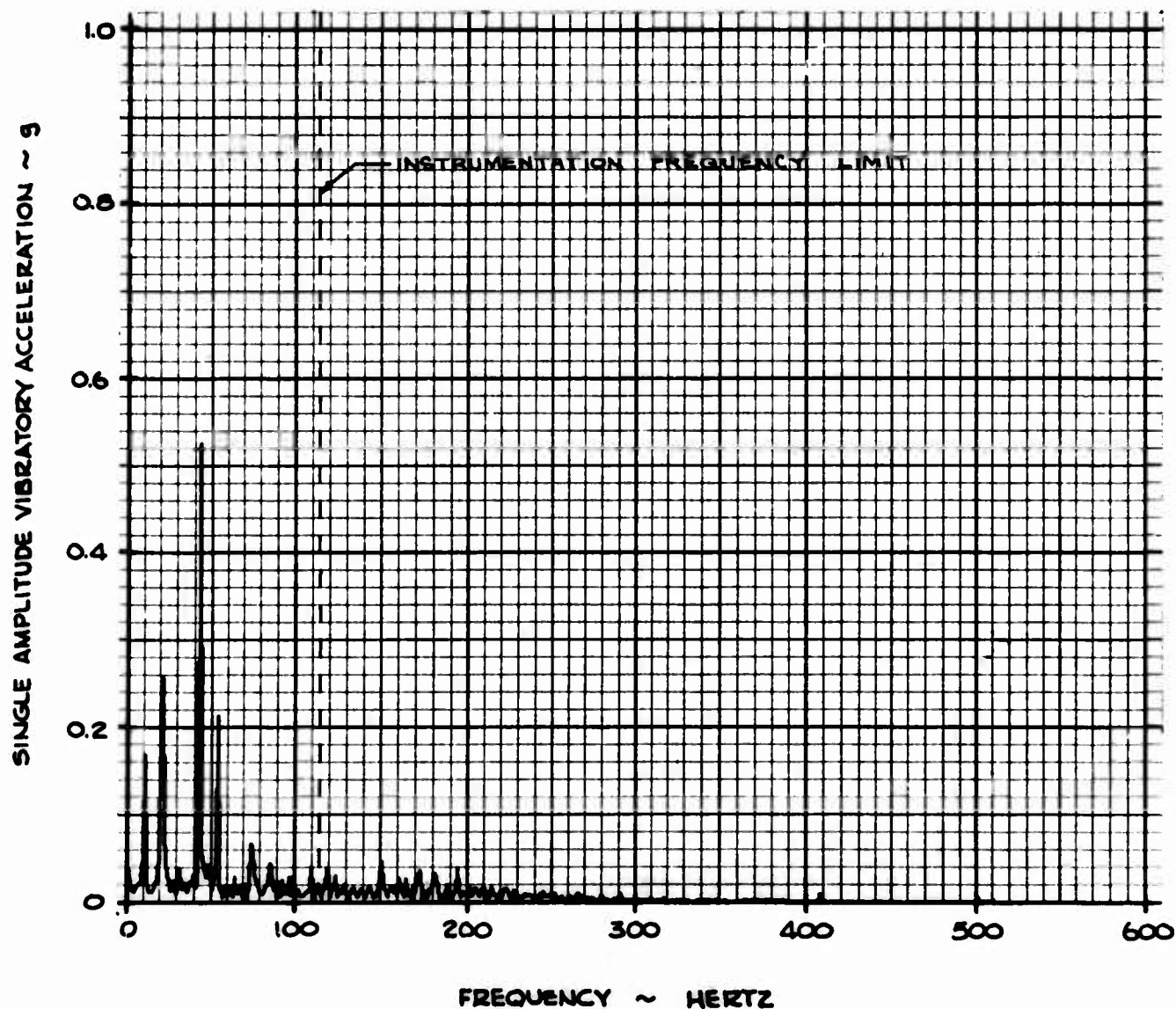


FIGURE 29
VIBRATION CHARACTERISTICS
AH-1Q USA S/N 70-16019
C.G. VERTICAL @ FS 196.7 BL -9.625 WL 69.25

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	AVG CT	SCAS CONFIGURATION	FLIGHT CONDITION
9230	196.3(MID)	5570	25.5	324	0.005412	ON	A
							1.45g SYMMETRICAL PULL UP AT 135 KCAS

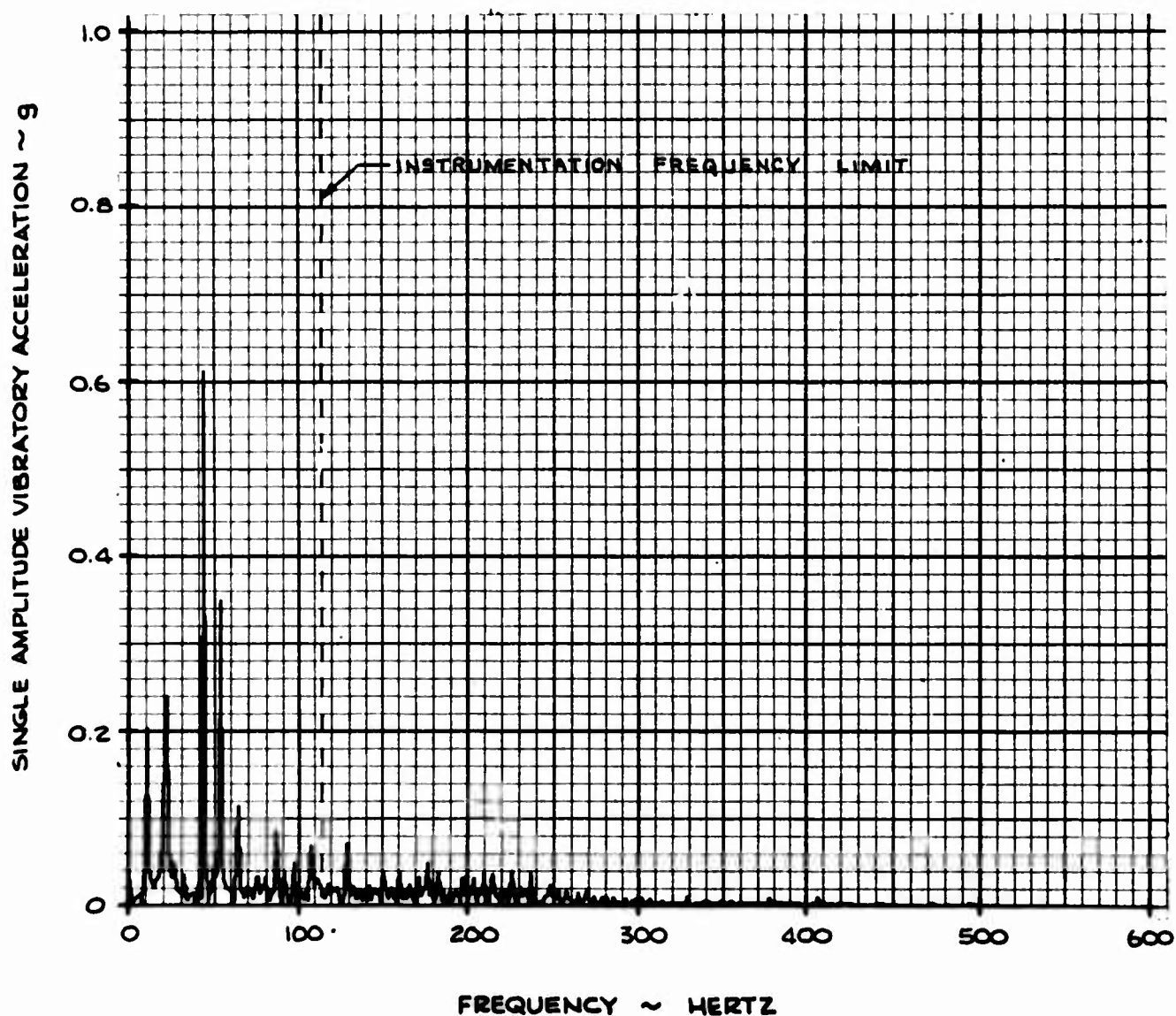


FIGURE 30
VIBRATION CHARACTERISTICS
AH-1Q USA S/N 70-16019
C.G. VERTICAL @ FS 196.7 BL -9.625 WL 69.25

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	AVG CT	SCAS CONFIGURATION	FLIGHT CONDITION
9230	196.3(MID)	5570	25.5	324	0.005412	ON A	1.58g SYMMETRICAL PULL UP AT 140 KCAS

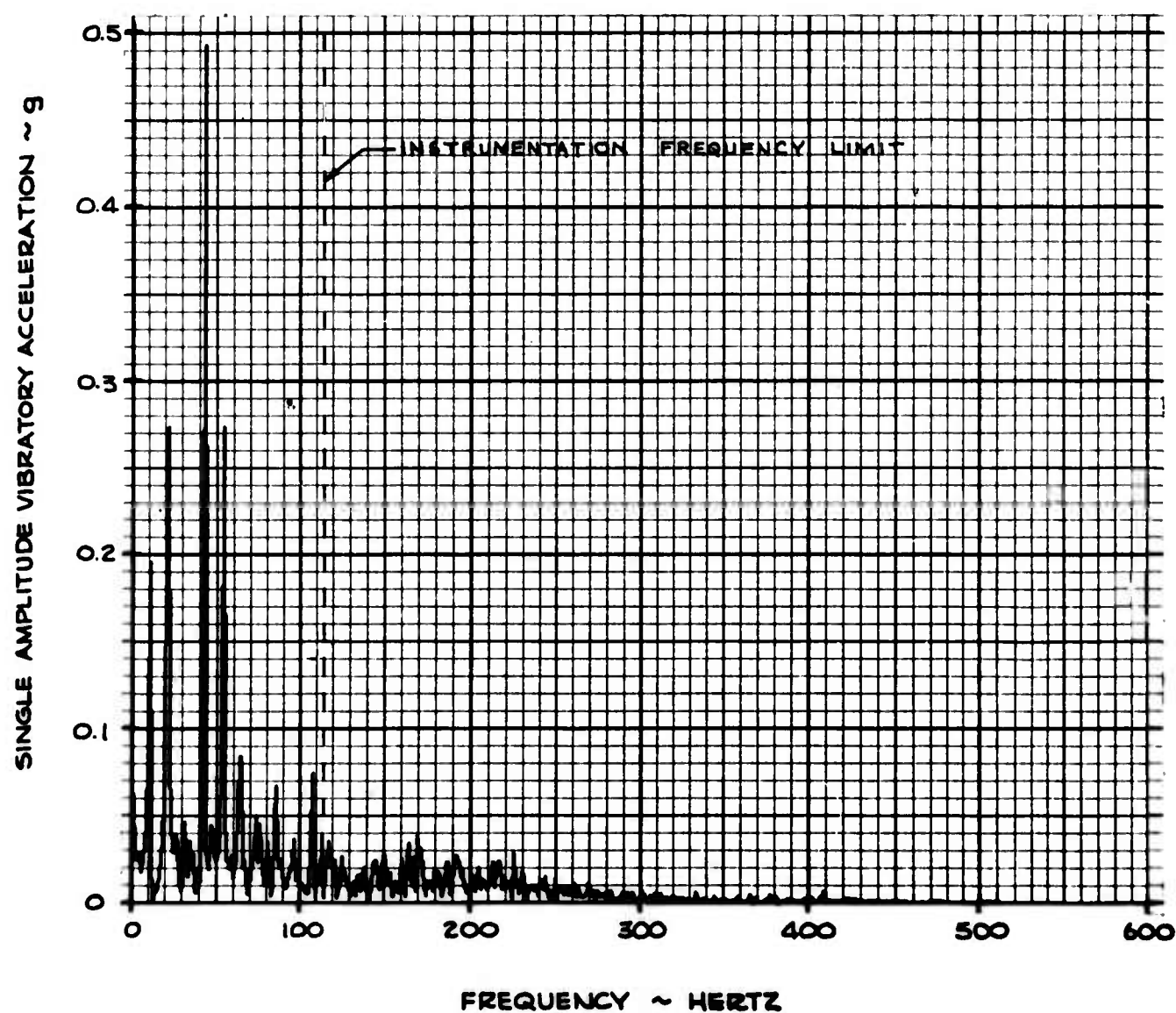
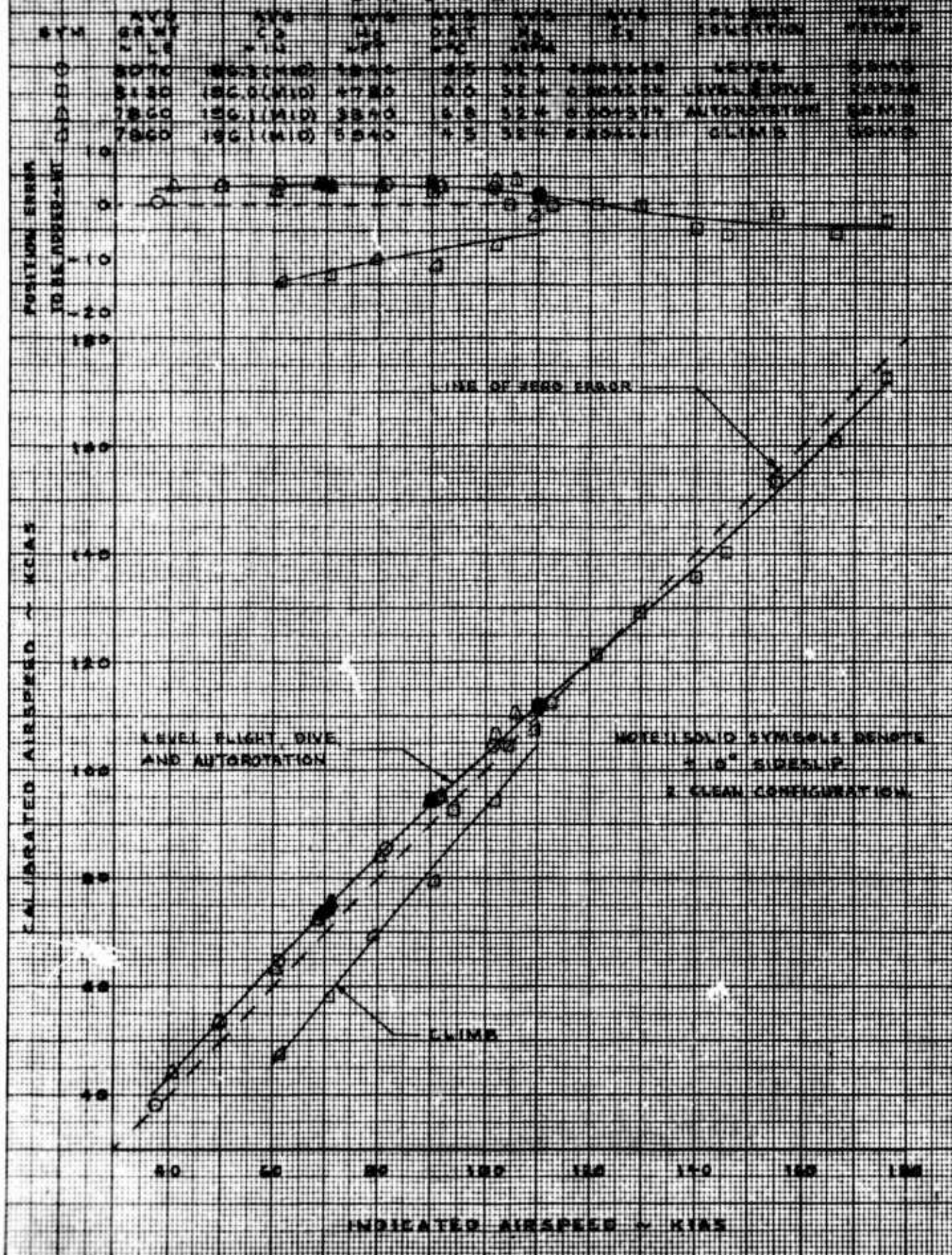


FIGURE 3
AIRSPEED CALIBRATION
AH-1Q USAF 5/4/70
DATA SYSTEM



UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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13. ABSTRACT			
<p>The United States Army Aviation Systems Test Activity conducted an Army Preliminary Evaluation of the improved Cobra armament system during the period 25 September to 20 October 1972. The testing was accomplished in three phases; (each subsequent to the contractor's testing) (1) handling qualities, (2) jettison envelope monitoring and verification, and (3) helmet sight subsystem qualitative evaluation. The testing was conducted at Bell Helicopter Plant No. 6, Arlington, Texas, and at Mojave, California. No deficiencies and seven shortcomings were noted. The shortcomings were (1) undamped lateral-directional oscillations with the stability control augmentation system OFF at 130 knots calibrated airspeed, (2) excessive four-, eight-, and ten-per-rotor-revolution vertical vibrations in symmetrical pull-ups, (3) inability of the helmet sight/M28A1 system to provide adequate range and speed compensation for the 40mm weapon system, (4) intermittent helmet sight reticle operation at the pilot station, (5) uncomfortable orientation of the gunner's left handgrip; (6) canted orientation of the pilot and gunner sight reticles, and (7) poor design of the turret action switch and trigger guard assembly. Seven conditions were noted that failed to satisfy the requirements of the military specification, MIL-H-8501A. The ship's airspeed system position error characteristics should be incorporated in the operator's manual. The helmet sight subsystem boresighting procedure should be improved prior to operational use.</p>			

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Army Preliminary Evaluation AH-1Q Helicopter Improved Cobra Armament System (ICAS) Handling qualities Jettison envelope monitoring and verification Helmet sight subsystem qualitative evaluation						